Tappi

PUBLISHED BY THE TECHNICAL ASSOCIATION OF THE PULP AND PAPER INDUSTRY

NOVEMBER 1949

Technical Advice...

in determining *your* particular needs

Laboratory Research...

to assist in solving sizing and other papermaking problems

Plant Assistance...

in applying the product to *your* processes

PREPARED SIZE +

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to assure consistently uniform results

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PP9-4

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In the heart of Wisconsin's woodlands, Rhinelander Paper Company is attaining new production peaks in the manufacture of high-grade glassine and greaseproof papers. Working side by side in the harness are "The Big Swede" and "Ripco Maid"... big modern Beloit machines, leaders in Rhinelander's notable seven-machine team. Beloit has been serving this company since 1903, when the No. 1 and No. 2 machines were built.—*Beloit Iron Works, Beloit, Wisconsin.*

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These Du Pont dyes are important for display papers, decorative tissues, wrapping paper, cover and construction paper . . . wherever brilliance of color is the outstanding requirement. For information about these dyes . . . or for help on any of your coloring problems . . . consult our Technical Staff. E. I. du Pont de Nemours & Co. (Inc.), Dyestuffs Div., Wilmington 98, Del.

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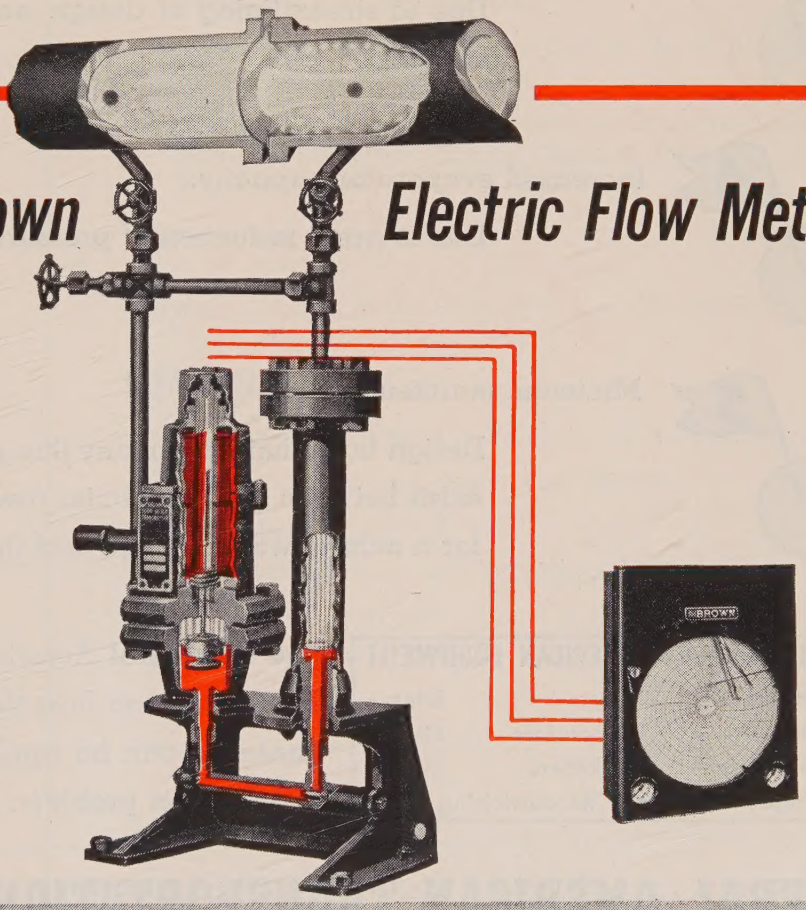

Write, today, for your copy of Catalog 2221 . . . for detailed information on flow control. For description of the complete Brown line for the Paper Industry, write for Bulletin 2801.

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Advanced Instrumentation
FOR THE PAPER INDUSTRY

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Erection time generally *one quarter* that required for other types.

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NOVEMBER 1949

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TECHNICAL ARTICLES

Technique of the Biochemical Oxygen Determination, *by D. Paul Rogers* 481

Bioassay of Slime Control Agents in a Pulp and Paper Mill System-I. Lignasan X and Merfenel, *by B. F. Shema, J. B. Anderson, and J. W. Appling* 489

Lengths of Hardwood Fibers and Vessel Segments—A Statistical Analysis of Forty-Nine Hardwoods Indigenous to the United States, *by Stuart I. Bergman* 494

Scattering and Absorption of Light in Paper and Other Diffusing Media—A Note on the Coefficients of the Kubelka-Munk Theory, *by J. A. Van den Akker* 498

The Dry-Indicator Method as a Test for Water Resistance, *by F. T. Carson* 501

Reseeding B.O.D. Bottles—A Means of Detecting Toxic Interference in the B.O.D. Test, *by George C. Borden Jr. and Irene Woodcock* 506

Abrasiveness Test for Paper Fillers, *by J. D. MacDonald and J. W. Kenney* 516

Sodium Silicates in the Paper Industry, *by Reynold C. Merrill* 520

DEPARTMENTS

Supply-Demand Data. I. Chemicals, *by Ruth E. Shallcross* . 14 A

The Paper Industry—A Stable Coal Market . . . . . 32 A

Fourth Engineering Conference . . . . . 38 A

United States Patents on Papermaking, *by C. J. West* . . . . 55 A

Local Section Activities . . . . . 64 A

Personal Mention . . . . . 78 A

Employment Service . . . . . 82 A

Floor Load Capacity Rating, *by C. S. Schroeder* . . . . . 84 A

TAPPI Standards . . . . . 88 A

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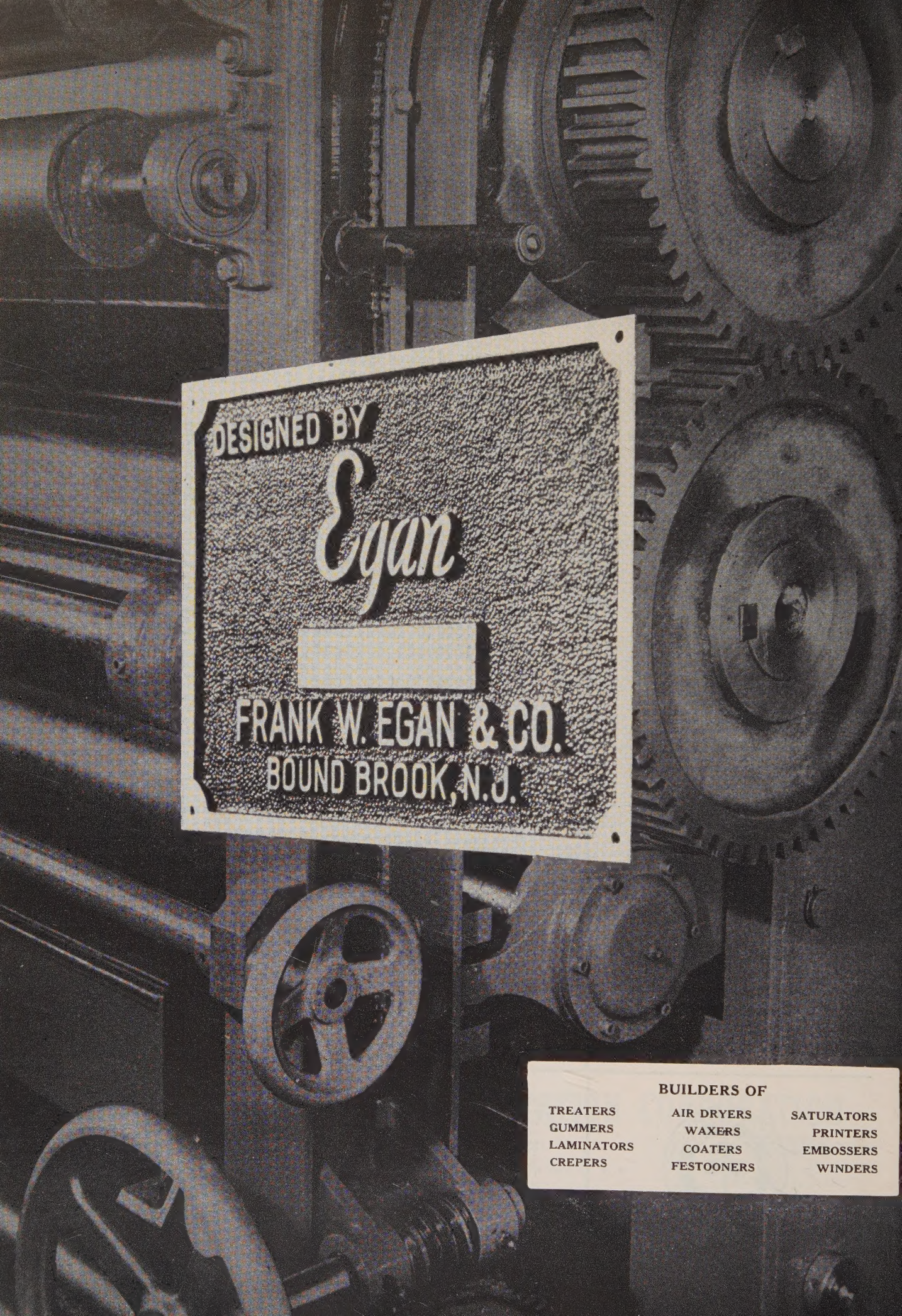

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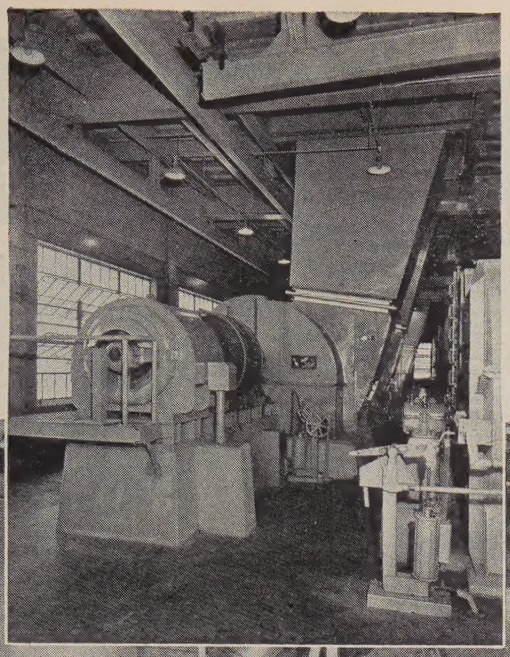
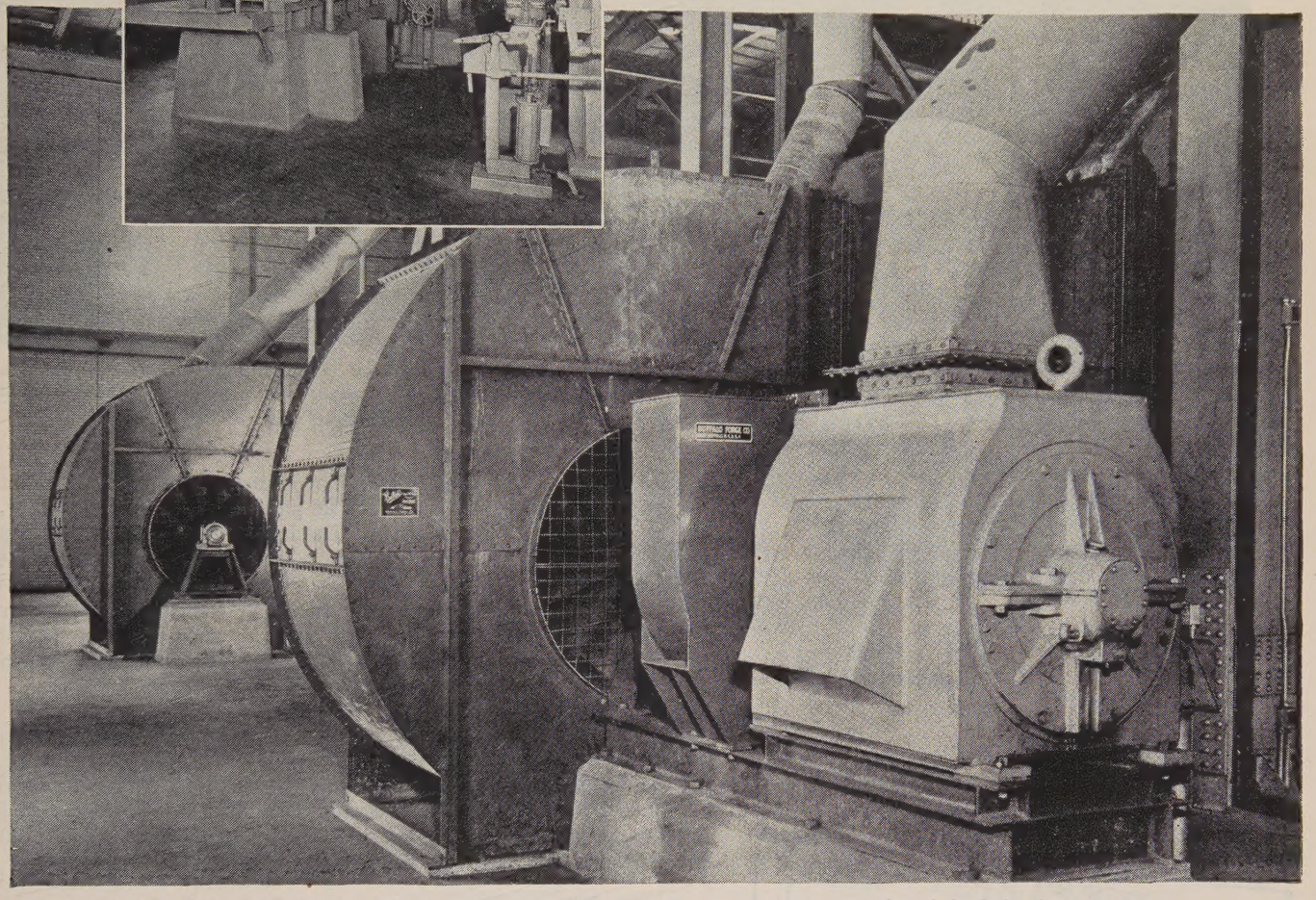


Making lower-cost horsepower! One of many big steam plants relying on rugged "Buffalo" Forced Draft Fans



"Buffalo" builds draft fans to handle many horsepower requirements. Above an induced draft fan in one unit of a plant turning out 1,775,000 pounds of 900°F. steam per hour.

In your drive to get operating costs down, look into *fundamental* costs that start right in the boiler room! With "Buffalo" Fans on the job, you save two ways—(1) fewer shutdowns for servicing and (2) quicker servicing when it is required. "Buffalo" builds high efficiency into draft fans, as it does in its other types of fans—but, even more important, builds these fans EXTRA HEAVY in all parts where wear can occur in the punishing draft job; builds housings, bearings and inlet boxes so that maintenance is quickly taken care of. Write for Bulletins 3190 and 3113-B, right, and see the rugged construction that makes "Buffalo" the choice of so many power engineers!

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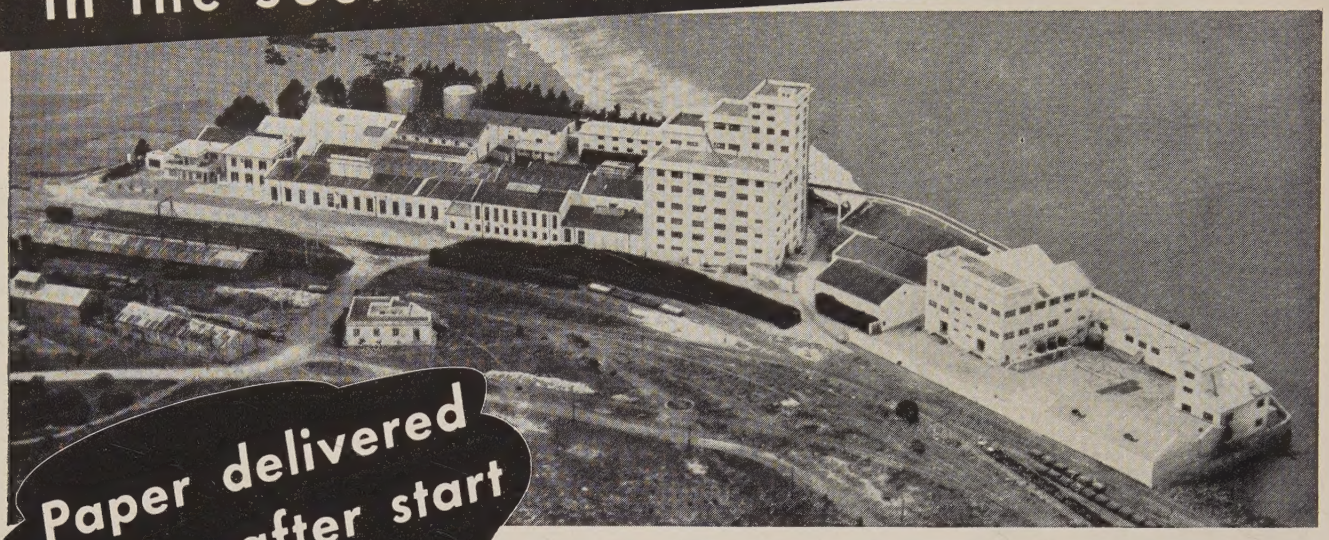
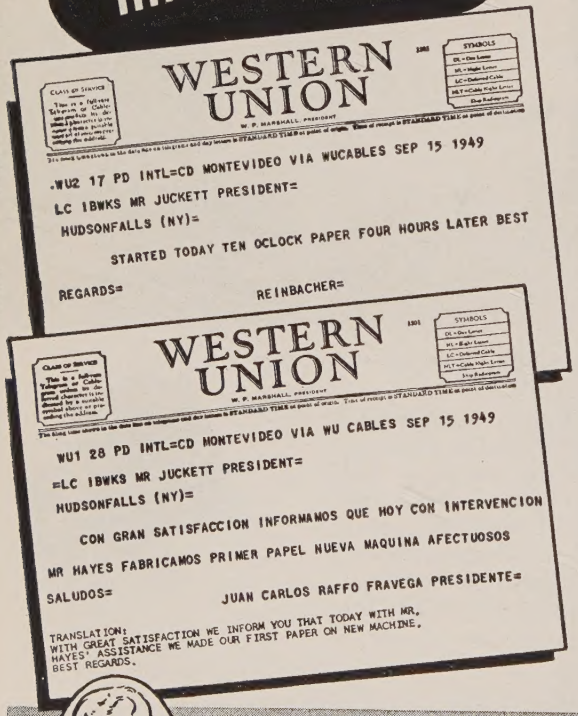
Sandy Hill Establishes a New Record in the South American Paper Industry



Plant of Fabrica Nacional de Papel in Montevideo, Uruguay. An additional machine (Number three) with process layout and equipment was supplied by The Sandy Hill Iron & Brass Works.

Paper delivered 4 hours after start of complete new mill installation!



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STARTED TODAY TEN OCLOCK PAPER FOUR HOURS LATER BEST

REGARDS= REINBACHER=

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MR HAYES FABRICAMOS PRIMER PAPEL HUEVA MAQUINA AFECTUOSOS

SALUDOS= JUAN CARLOS RAFFO FRAVEGA PRESIDENTE=

TRANSLATION:
WITH GREAT SATISFACTION WE INFORM YOU THAT TODAY WITH MR. HAYES' ASSISTANCE WE MADE OUR FIRST PAPER ON NEW MACHINE.
BEST REGARDS.

FNP
EL SAUCE

Destined to be one of the world's largest producers of fine paper from bleached straw, the Fabrica Nacional de Papel mill has started operation of a new modern unit at Montevideo, Uruguay, with a record breaking accomplishment! A starting time of four hours is very nearly record after small changes in a paper mill, and is probably an all-time record for a completely new mill installation.

In addition to the design and layout of the paper machine, Sandy Hill engineers made complete plans for the basement, for the auxiliaries and for all phases of the mill piping system. The material shipped from Sandy Hill and its suppliers and loaded onto ships in New York harbor would have filled 40 freight cars.

Sandy Hill equipment used in this installation include a Sandy Hill-Bertrams Flow Control System, Bertrams Shake, Sandy Hill-Spencer Electrical Dandy Roll Drive, Sandy Hill Open Side Calender Stacks, Pope type Constant Speed Reel, Selective Drive and Sandy Hill-Scofield Felt Conditioning equipment.

The starting of this modern, highly efficient equipment for manufacturing straw into fine paper marks a significant milestone in the further rapid development of the paper industry in South America and another triumph for Sandy Hill paper mill engineering.

Sandy Hill Iron & Brass Works

Hudson Falls, N. Y.

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Some Leading Items:
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Dandy Roll Drives
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Cleveland Type Bearings
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"ALBONE" 50
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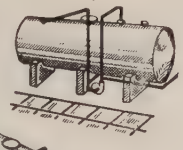
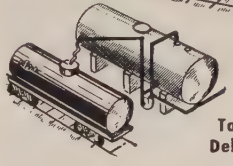
For GREATEST ECONOMY, CONSIDER:

Tank Storage at the Mill





Tank Car Deliveries

If you need 5000 lbs. or more of "Albone" 35 Hydrogen Peroxide per month, you'll find a storage tank installation economical.

These high-quality Du Pont peroxides for groundwood bleaching are available in quantity . . . drums and tank cars. All three peroxides are highly stable under normal storage conditions.

Excellent and economical bleaching of groundwood can be carried out with either "Albone" or "Solozone" or a combination of "Albone" and "Solozone."

For valuable assistance with bleaching problems, the technical advice of the men who pioneered the development of groundwood bleaching is available. These Du Pont technical men will assist you in planning, installing, operating and maintaining a peroxide system for bleaching groundwood.

SEND FOR BOOKLET and other literature describing Groundwood Bleaching. Learn how easily the system can be set up and operated in your plant. Just clip the coupon below and mail it today.

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*Address*_____

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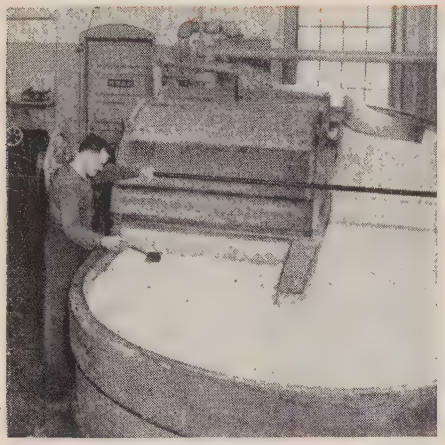
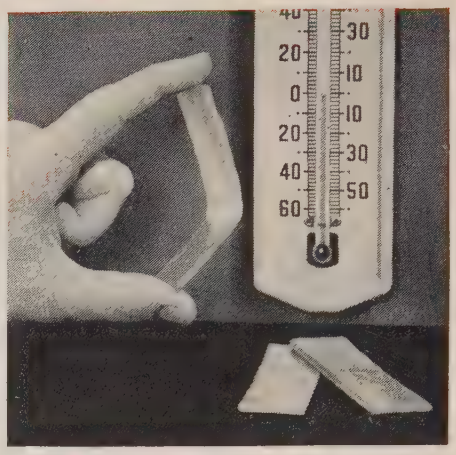
Get Processing Help Here!



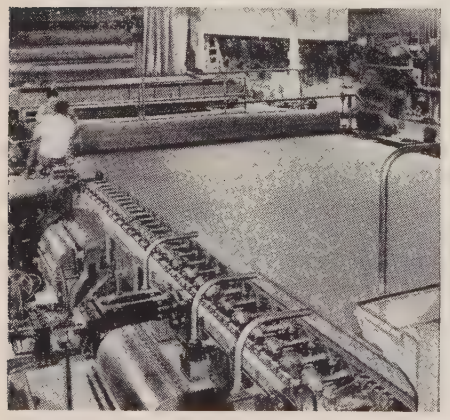
● **WAX EMULSIONS**... S/V Ceremuls provide concentrated wax sizes for beater and surface treatment. Some are resistant to breakdown due to hard water and acid conditions. They improve finish, add water resistance and reduce curl.

These superior Socony-Vacuum products will improve your operations and your finished papers.

They're backed by skilled technical service to assist in correct application and help in the development of new products where needed.

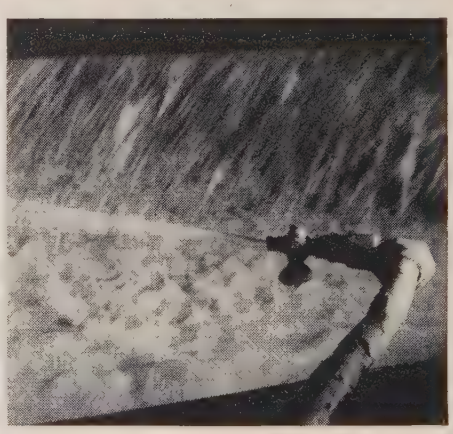


● **MICROCRYSTALLINE WAXES** . . . Improved S/V Magnowaxes have greater adhesiveness and improved low temperature flexibility. These features insure a durable seal and an effective wax barrier in refrigeration service.



● **PITCH CONTROL** . . . S/V Sovalents reduce difficulties due to pitch. S/V Sovalent 911 attacks pitch in the digester and speeds production. S/V Sovalents 21 and 31 attack pitch on paper machines and reduce downtime.

● **SPECIALTY PRODUCTS.** These include: S/V Prorex Oil P, for oiled papers; S/V Cellusorb A, for toweling, tissues; S/V Ceremuls for vinyl coatings; S/V Antioxidant W, to prevent the development of rancidity in wax baths.



● **DEFOAMANTS** . . . S/V Foamrexes give complete foam control, at low cost. These Socony-Vacuum products attack the foam instantly. They provide better formation and speed production. They are easily handled and easily applied.

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Process Products
SOCONY VACUUM

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WITHIN A Gnat's Eyelash

We haven't the faintest idea as to the diameter of a gnat's eyelash (and care less), but we do know that the new Downingtown Duplex Cutter and Slitter gives accuracy of sheet length to within .0625 which everyone knows is cutting to "within a gnat's eyelash." You're assured of this kind of accuracy and positive squareness of the sheet with the completely re-designed, modern Downingtown Duplex Cutter and Slitter, because of its POSITIVE DRIVE ADJUSTMENT. Unique features, not found in any other machines of this type, assure (1) greatly reduced secondary trimming (2) absolutely minimum wastage (3) continuous high speed operation (all bearings are oversize, anti-friction type), (4) ease of passing sheet and (5) ease and simplicity of slitter adjustment or removal, while running.

This new Downingtown Duplex Cutter and Slitter "must be good," because it hasn't been on the market very long and already eight have been sold, which includes a repeat order from one customer. What more need we say, other than to remind you that, if you want to reduce your cutting and slitting spoilage and maintenance to "within a gnat's eyelash," fill in and mail the coupon today.

BLUEPRINT FREE—NO OBLIGATION

Downingtown Mfg. Co.
Downingtown 7, Pa.
Please send me a blueprint of your new Duplex Cutter and Slitter, and a summary of its many unique features.

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Title _____

Company _____

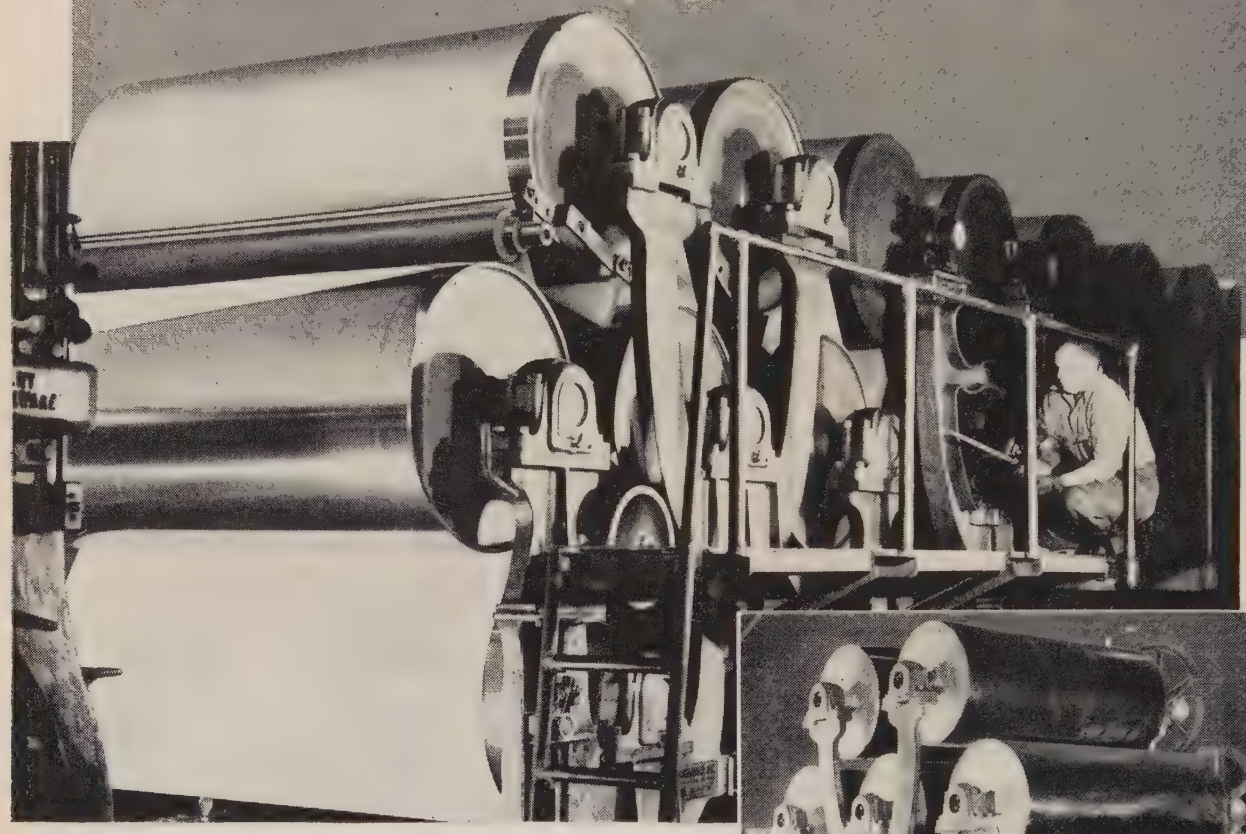
Address _____

DOWNINGTOWN MANUFACTURING COMPANY

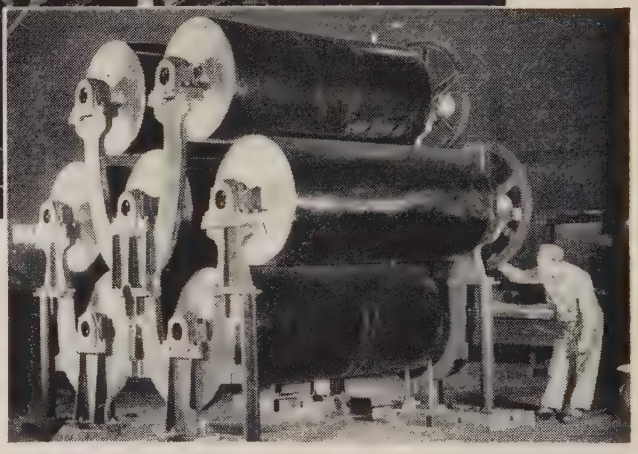
DOWNINGTOWN, PA.

DESIGNERS AND BUILDERS OF PAPER MAKING MACHINERY SINCE 1880

7 LUKENWELD DRIER ROLLS do the work of 10 ordinary rolls...



This drier section addition to a paperboard machine at S. Austin Bicking Paper Mfg. Co., Downingtown, Pa., packs a lot of production into a small space.



Erecting the drier section at Lukenweld

To increase the output from one of S. Austin Bicking Paper Manufacturing Company's paperboard machines, it was estimated that ten ordinary single-shell rolls would be required. Our engineers determined that seven Lukenweld Jacketed Steel Drier Rolls would provide the desired additional drying capacity.

Lukenweld designed and built the drier section containing these seven rolls. Because fewer rolls were required, the unit takes up less plant space, the supporting structure was simplified and costs were reduced. The welded steel frame is strong and rigid, helping hold down upkeep costs.

Lukenweld Jacketed Steel Drier Rolls owe their superior performance to these properties: Narrow passages force high-speed steam circulation and positive scavenging. Being of steel plate construction, sections can be thinner, assuring rapid and uniform heat transfer. These rolls can be safely worked at high steam pressures—up to 350 psi and higher.

Manufacturers interested in increasing the output from old or new machines can obtain help from our engineers. Bulletin 358 tells you more about Lukenweld Jacketed Steel Drier Rolls; Bulletin 505 gives actual case histories on applications in various industries. For copies, write Lukenweld, Division of Lukens Steel Company, 501 Lukens Bldg., Coatesville, Pa.

LUKENS

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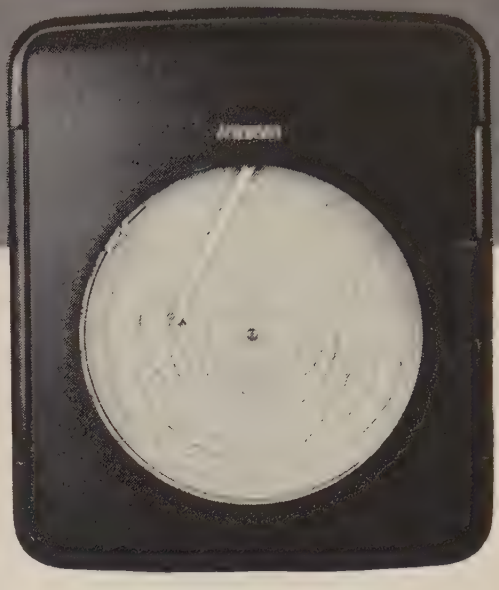

Employing only one measuring system, the new Foxboro Multi-Record Dynalog gives up to 6 clean-cut records in as many different colors on one convenient *round* chart. The ingenious, foolproof switching arrangement provides recordings in sequence every 6 seconds—so close that the record of each measurement appears as a continuous line. The record colors positively will not run together.

Like all Dynalog Electronic Instruments, balancing from any measurement point is entirely *stepless* and continuous. Its combination of accuracy, speed and sensitivity is unequalled.

The Multi-Record Dynalog is available for measuring several temperatures or other process variables. Send for Bulletin 428. **The Foxboro Company, 78 Neponset Avenue, Foxboro, Mass., U. S. A.**

TYPICAL APPLICATIONS IN PULP AND PAPER PLANTS

Digesters — **Evaporators**
Causticizing Systems — **Power Plants**
Roll Surface Temperatures

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Learn how this unique instrument improves and simplifies operation . . . reduces overall costs and instrument costs.

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Another FOXBORO FIRST

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Supply-Demand Data on the Chief Nonfibrous Raw Materials Used in the Pulp and Paper Industry

*I. Chemicals Used in the Manufacture of Pulp**

RUTH E. SHALLCROSS

LONG AGO the pulp and paper industry accepted the belief that accurate statistics and fundamental economic data are a necessary basis for making forecasts, whether the plans based on the forecasts include expansion of capacity or an improvement of present production. During World War II, the War Production Board provided data on many industry activities that previously had not been recorded officially, and many mill executives found them highly valuable, began to depend upon them, and now want the continued recording of certain statistical series.

Most of the data collected during the war were for fibrous raw materials used by the pulp and paper mills—pulpwood, rags, wastepaper, etc. Very little information has been available on nonfibrous raw materials, except for estimated use-patterns for the scarcer chemicals drawn up by the Chemicals Division of the War Production Board.

Numerous requests have come to The Institute of Paper Chemistry with regard to the supply-demand situation of a particular pulp or papermaking chemical. Many are surprised that data on the industry's consumption of various chemicals are not readily available. Therefore, a discussion of the supply-demand picture pointing up the dark spots (the gaps), as well as the highlights (the availability of data), is in order.

Lack of knowledge concerning the demand for chemicals used in pulp and paper manufacture is even more amazing when it is realized that the pulp and paper industry was, for a number of years, the second largest consumer of all industrial chemicals when the chemical industry itself is omitted. It is still the third largest user. The fertilizer industry is first, as is shown in Fig. 1 and Table I. The glass manufacturers have challenged the papermakers for second place in some few years, and the paint, varnish, and lacquer manufacturers took second place in 1947, but fell back in 1948 when the rayon industry held second place.

Several government agencies collect supply data on industrial chemicals in which paper manufacturers are interested, but consumption data by industries are available for only a few pulp and paper chemicals. It would seem that, for security reasons alone, the government would be making surveys which would show not only the raw material resources and facilities for manufacturing important chemicals, but also the chief industrial consumers. Data should be available over a sufficiently long period so that secular trends could be determined and industry requirements accurately established. Yearly fluctuations and the recent expansion in capacity make it hazardous to take a single year as indicative of what the pulp and paper industry will need in the future. Many of the

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Ruth E. Shallcross

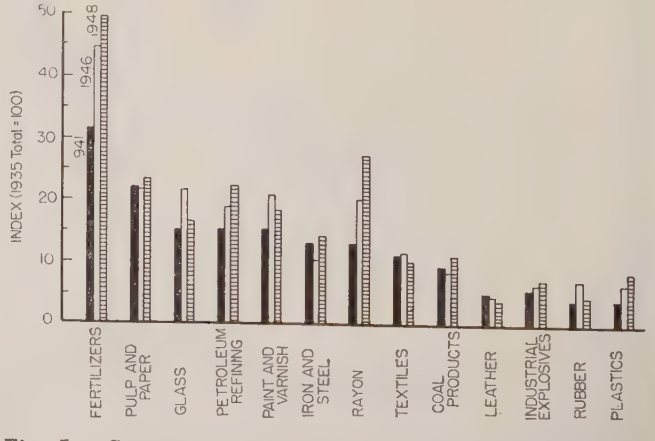

Fig. 1. Comparison of consumption levels of chemicals by various industries, 1941, 1946, 1948

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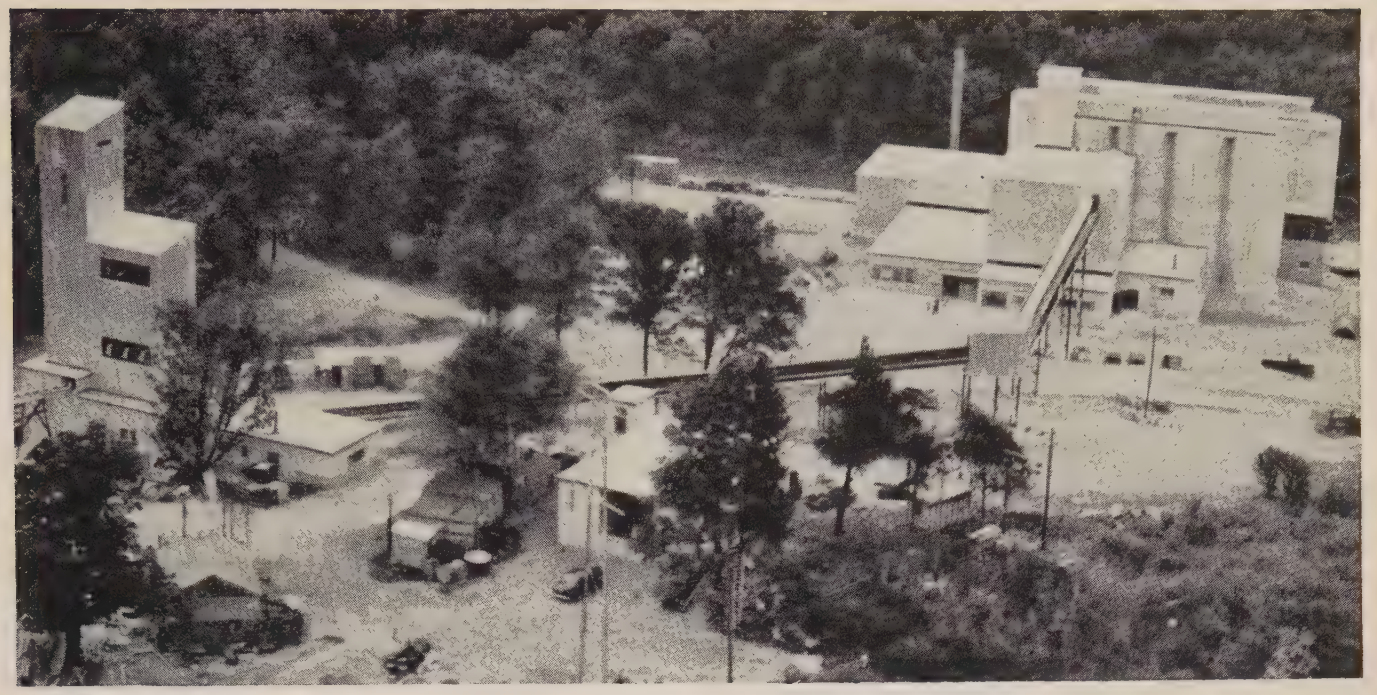
OUR NEW TALC PLANT



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NYTAL

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Table I. Industrial Consumption of Chemicals

Index—1935 = 100

	1939	1941	1942	1943	1944	1945	1946	1947	1948[a]
Fertilizers	25.13	31.49	37.33	40.12	39.76	42.21	44.70	50.88	49.60
Pulp and paper	16.52	21.92	20.51	19.05	18.87	19.44	21.70	22.80	23.30
Glass	12.51	15.03	15.91	18.80	19.93	19.64	21.65	21.83	16.35
Petroleum refining	13.45	15.20	14.43	15.56	18.10	18.71	18.82	20.02	22.21
Paint, varnish, and lacquer	10.66	15.03	14.35	15.40	16.71	17.37	20.80	24.55	18.26
Iron and steel	8.21	12.88	13.32	13.49	13.33	11.96	10.20	13.01	14.30
Rayon	9.08	12.87	14.93	15.53	16.81	18.38	20.02	22.74	27.15
Textiles	7.89	11.06	11.97	11.43	10.53	10.30	11.25	11.05	10.08
Coal products	7.17	9.28	9.54	9.47	10.05	9.41	8.15	10.23	11.10
Leather	4.16	4.88	4.88	4.56	4.25	4.54	4.60	4.83	3.94
Industrial explosives	4.53	5.54	5.73	5.52	5.06	5.36	6.30	7.44	7.28
Rubber	2.79	3.91	3.00	3.00	3.00	4.55	6.85	5.98	4.81
Plastics	2.05	3.71	4.36	4.80	5.24	5.75	6.48	7.37	8.64
Total	124.15	162.80	170.26	176.73	181.64	187.62	201.62	222.73	217.02

Source: Wilson, J. D., and Keezer, D. M., *Chem. Eng.* 54, No. 2:95 (Feb., 1947); 55, No. 2: 100 (Feb., 1948); Warren, R. F., *Chem. Eng.*, 56 No. 4: 303 (April, 1949).

[a] December index.

(continued from page 14 A)

government departments have recently had their survey budgets cut. Therefore, the statistics on chemical consumption which the government does not already collect and give to industry will have to be collected by private agencies if they are to be available.

The chemicals industry is vitally interested in the consumption pattern of its own products and the forces which are affecting and altering that pattern. Consequently, that industry is bringing the most pressure to bear on government departments to collect more statistics which will show use-patterns. Moreover, the chemical companies, in their desire to know their markets, potential and real, must estimate how much of the market they are currently holding. Therefore, when official statistics are lacking, they are the best source for estimates of the total chemical market and the consumption by industries. It is to such sources that we must turn for our information until more accurate data are collected by either government or private agencies.

Figure 2 illustrates graphically the chemicals used in the pulp and paper industry. It indicates that the main chemicals necessary for the pulping process are lime, caustic soda, soda ash, chlorine, sulphur, salt, and limestone. The resources of these minerals are fairly easily evaluated, even though the chemical requirements for pulp manufacture are not as easily established. The chemical which a particular pulp mill decides to use, of course, depends on the market situation for it in relation to the market for substitutes which might be used. No particular mill over a number of years, therefore, will follow exactly the pattern of chemical use shown in the outline.

As an illustration, specialty papers utilize a variety of chemicals. Some of these are: *abrasive papers*—aluminum oxide, silicon carbide, garnet, or flint, with glue; *adhesive papers*—glue, starch, casein, sodium silicate, or latex; *blue and brown print papers*—potassium ferricyanide, potassium dichromate, and iron salts; *cigarette paper*—calcium carbonate, some nitrate; *decorative papers*—lacquers and varnishes made from resins, solvents, and driers; *fireproof paper*—ammonium sulphate and diammonium phosphate; *gypsum liner*—gypsum; *leatherboard*—latex; *photographic papers*—barium sulphate; *vegetable parchment*—sulphuric acid; *waterproof papers*—asphalt; *waxed papers*—wax; *wet-strength papers*—wet-strength resins.

SULPHUR

Sulphur is the principal nonfibrous raw material used in the sulphite and semichemical pulping processes; from 200–300 pounds are required per ton of sulphite pulp and about 75 pounds per ton of semichemical pulp (see Fig. 2). The industry also uses small amounts of sulphuric acid directly in cleaning in the mill and considerable amounts indirectly in the chemicals made from sulphuric acid. As a consumer of mined sulphur, the pulp and paper industry ranks third in the list of industrial users (*21*). The chemicals industry ranks first; three fourths of all sulphur mined is transformed into sulphuric acid, which, in turn, is used for the manufacture of a number of products of interest to the pulp and paper industry. The fertilizer industry ranks second. In 1933, the pulp and paper industry took approximately 17% of the total supply of mined sulphur. But in 1945, when the total amount consumed nearly tripled

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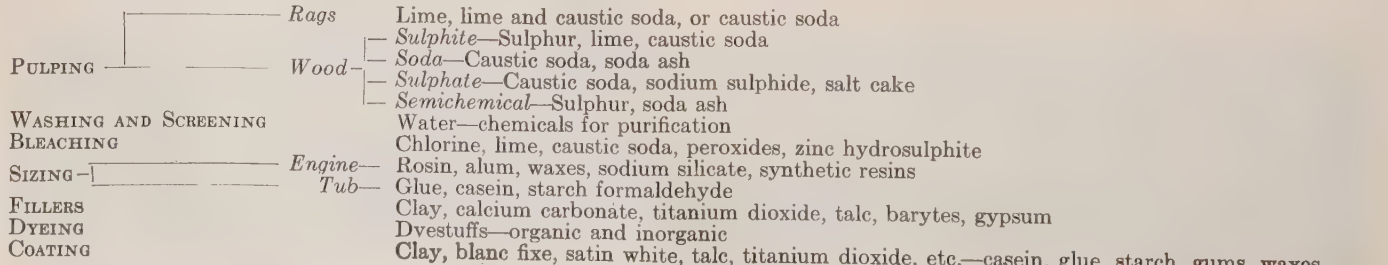
Fig. 2. Basic chemicals used in pulp and paper manufacture



Putting a Blanket of Air

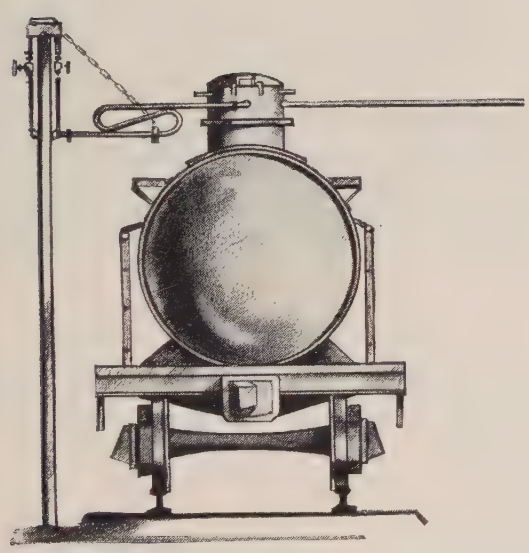
on Chlorine

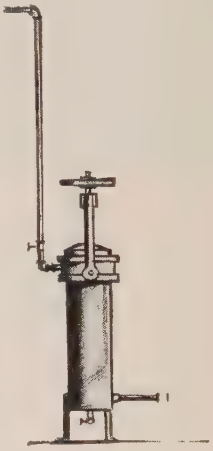
The development of a chlorine evaporator that maintained a constant gas temperature solved only a portion of the chlorine flow problem. Hooker engineers next tackled the problem of keeping the pressure constant. This was solved by applying regulated air pressure to the liquid chlorine in the tank car.

A relatively simple air cooler and drier was designed and constructed to operate in conjunction with an automatically regulated air compressor.

Another problem, that of preventing the corrosive action created by the backflow of chlorine in the air system, was also solved. To prevent this backflow, a new check valve was developed with two 7½ pound plungers. These plungers placed a mechanical pressure on the seat of the valve at the time of closure and assured a greater degree of safety against leakage of chlorine. The sum total of the two plungers being 15 pounds, pressure of the air system was maintained at 15 pounds higher than the pressure of the chlorine system.

These advances in the safe and convenient handling of chlorine are only part of the story of Hooker's long and close relationship with the pulp and paper industry. Hooker continues to provide helpful service by supplying uniform high quality chlorine, caustic soda and other chemicals. For your pulp and paper making you can always depend upon Hooker Chemicals.





HOOKER CHEMICALS

HOOKER ELECTROCHEMICAL COMPANY
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New York, New York • Wilmington, California • Tacoma, Washington

8-721 Caustic Soda Muriatic Acid Sodium Sulfide Paradichlorobenxene Sodium Sulfhydrate Chlorine

Table II. Sulphur Consumed in the United States by Uses (1000 Long Tons)

	Chemicals	Fertilizer and insecticides	Pulp and paper	Percentage of Total	Explosives	Dyes and coal-tar products	Rubber	Paint and varnish	Food products	Miscellaneous	Total[a]
1929	598	415	265	16.3	67	47	43	5	5	137	1582
1933	491	242	197	17.3	37	40	24	4	4	75	1114
1936	620	266	260	18.2	53	46	39	54	5	78	1421
1937[b]	777	415	302	16.9	68	49	37	64	6	82	1800
1938[b]	484	220	174	15.9	50	40	29	50	6	48	1100
1939	695	370	240	15.0	64	46	43	49	6	82	1595
1940	800	410	320	17.3	74	51	47	54	6	86	1848
1941	1060[c]	450	360	16.1	83[c]	65	55	65	6	95	2239
1942	1260[c]	475	365	14.7	90[c]	60	35	70	6	110	2471
1943	1320[c]	500	305	12.1	90[c]	65	45	80	7	120	2532
1944	1585[c]	580	300	10.3	88[c]	75	55	90	7	140	2920
1945	1605[c]	600	297	10.0	90[c]	75	58	94	7	135	2961

[a] Discrepancy between total and sum of individual groups due to rounding.
[b] Represents shipments. Consumers carried over large stocks into 1938, therefore consumption was larger than shipments.
[c] Military explosives included under "Chemicals" to avoid disclosure of direct defense applications.
Source: Bureau of Mines [National Industrial Conference Board, Chemicals. I. Basic Industrial Chemicals, 1947, Table 12].

(continued from page 16 A)

the 1933 figure, the paper industry's use decreased from the peak of 1941–1942 to about 10% of the total, as shown in Table II.

The paper industry had no need for sulphur until Tilghman discovered the sulphite method of pulping wood in 1866–1867 (*18*). In the early days of pulping by that method, the industry obtained its sulphur from Sicily in the form of ingots. However, at the turn of the last century, with the opening of the Louisiana-Texas mines (which use the Frasch method of mining), the United states began to compete for world supremacy in sulphur production, which she captured after World War I (*20*).

The growth increase in sulphur consumption in the United States since the sulphite process was discovered is shown in Table III and Fig. 3.

Table III. Production of Sulphur (1000 Long Tons)

(Yearly Figures Based on Monthly Averages Times 12)

1927	2111	1938	2305
1928	1970	1939	2088
1929	2358	1940	2725
1930	2558	1941	3132
1931	2130	1942	3456
1932	930	1943	2539
1933	1387	1944	3218
1934	1417	1945	2754
1935	1627	1946	3859
1936	2012	1947	4441
1937	2677	1948	4869

Source: Texas State Comptroller and the Supervisor of Public Accounts of Louisiana through 1939; 1940–1946 data from the Bureau of Mines, as summarized by the Natl. Industrial Conference Board in The Economic Almanac, 1945–1946, p. 241, 1948, p. 226; and 1949, p. 364.

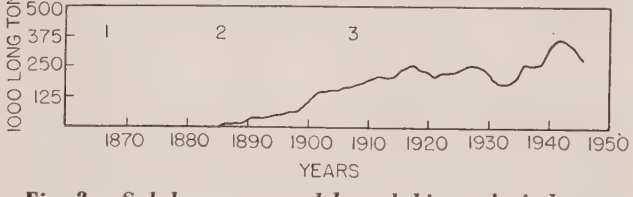

Fig. 3. Sulphur consumed by sulphite pulp industry

All forms (sulphur, pyrites, smelter gas) in equivalent tons; 3-year averages, centered. (1) Sulphite process discovered (1866); (2) Sulphite pulp produced (1885); and (3) Sulphate pulp produced (1907). Source: Data from 1940 on, from Bureau of Mines as reported in (*7*)

Dewhurst and Associates (*17*) state that we produced 83% of the world supply of sulphur in 1937 and consumed 54% of the world consumption. That our present resources will not be with us always is evident by their warning that the brimstone in the salt domes of the Gulf Coast States at the present rate of consumption "will last only about 15 years." Then, they say, we will "have to turn to the pyrite deposits of the Southeastern and Western states, to the byproduct sources at copper and zinc plants, and to the purification of sour petroleum and of natural and manufactured gas." We could also turn to the recovery of sulphur dioxide from the stack gases of large steam power plants. The Bureau of Mines is of the opinion that we can also rely on gypsum as a source of sulphur.

Pyrites are used for some purposes—e.g., sulphuric acid—when they are free from copper, lead, and zinc and are no more expensive in terms of price of recoverable sulphur at the mill, but the United States pulp mills at the present time do not use them. Pyrites are used extensively for sulphite acid manufacture in Canada and Europe. The constant competition between alternate raw materials may allow pyrites to gain the ascendancy when the cost of mining sulphur reaches the point where price and quality are in their favor. This may come within the next 15 years or, if new deposits are found, sometime after that. Sulphur has shown a remarkable stability in price for the last 20 years which would not reflect any present serious threat of a depletion of resources. Supply has been ample for some time now and present inventories reflect no cause for alarm. However, the eventual decline of the native sulphur supply must be taken into account in any future planning. Because of the importance which sulphur plays in the paper industry, the total supply and demand situation needs to be constantly surveyed, not only in terms of current market quotations but in terms of the possible increase in demand from new industries, from those which have already found it indispensable, and in terms of the possible depletion of resources from known deposits.

SALT

Salt (sodium chloride), which occurs abundantly in nature in all parts of the world and in most regions of the United States, is the direct source of the several sodium compounds used by the pulp manufacturers—compounds such as soda ash, caustic soda (sodium hydroxide), sodium sulphate, and chlorine. These compounds are sometimes mined as they occur in nature—e.g., soda ash and salt cake—and they are sometimes

(continued on page 20 A)

Crystallizing Your Ideas

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DESIGNERS AND BUILDERS OF PAPER MAKING MACHINERY

WATERTOWN, NEW YORK

(continued from page 18 A)

produced without salt, although, in most of the manufactured products, either salt is used directly or a product from salt is used as a raw material.

Chemical companies transform natural salt into many products for industrial use and thus have aided man on his long road of mastering his material environment. Fortunately, this country has never penalized the transformation of the common and abundant commodity, salt, into its many useful products by placing a tax on it as some other countries have done. The paper industry can be thankful for this, because the salt products so necessary to papermaking would have cost much more than they now do if such had been the case. Salt in its native form is not used to any great extent by the paper industry, unless a company makes its own caustic or chlorine.

CAUSTIC SODA

Electrolytically produced caustic soda (sodium hydroxide) is one of the most important forms in which the paper industry uses salt. Inasmuch as caustic soda is produced along with chlorine, which has become the more important product economically, it

Table IV. Estimated Caustic Soda Consumption

Year	Total, 1000 short tons	Pulp and paper industry	
		1000 short tons	%
1928	595	33	5.5
1930	652	42	6.5
1932	587	34	5.8
1934	670	37	5.6
1936	796	46	5.8
1938	865	37	4.3
1940	1118	78	6.9
1942	1464	85	5.8
1944	1884	100	5.3
1946	1870	115	6.2
1947	2130	130	6.1
1948	2333	140	6.0

Source: Estimates of *Chemical Engineering;* 1946 and 1947 are revised.

Table V. Production of Sodium Hydroxide—Electrolytic and Lime Soda Process (1000 Short Tons)

1921	239	1939	1025
1923	437	1940	1100
1925	497	1941	1429
1927	573	1942	1574
1929	762	1943	1700
1931	689	1944	1875
1933	687	1945	1864
1935	759	1946	1873
1937	969	1947	2080
		1948	2358

Source: Bureau of Census, as published in *Chemical Engineering* 55, No. 2: 107 (Feb., 1948), and in The Economic Almanac for 1945–1946, p. 240 and 1948, p. 227, supplemented by reports in The Industry Reports for Chemicals and Drugs, U. S. Department of Commerce. Data exclude government-owned and operated plants. Prior to 1939, data exclude the tonnages made and consumed by wood pulp mills, which is estimated by the staff of *Chemical Engineering* to be as follows:

1927,1929	30,000
1931	24,000
1933	21,000
1934	20,000
1935	17,000
1936–1937	19,000
1938	18,000

was produced in supplies greater than the demand during most of the prewar years. For 20 years, the low price has varied very little. As the supply increased, the paper industry has increased its use of it so that it has taken approximately 6% of the total supply every year on the average since 1927 even though its consumption has more than tripled since then (*2*). The supply is still not quite sufficient to meet the extraordinary demands, but they are slowly being met by additional plant capacity. However, if chlorine is produced without the byproduct caustic soda, the production of caustic will be seriously affected and the change will, of course, be reflected in the price.

No official census data exist as to the distribution of the supply of caustic soda, but *Chemical Engineering* has estimated the use-patterns for many years and the U. S. Department of Commerce has data on production. Consumption and production data are shown in Tables IV and V.

There is need for an accurate census, at least occasionally, on the distribution of the caustic soda supply among industries in order to check the accuracy of the estimates.

CHLORINE

Chlorine is another product used in great quantities by the paper industry and obtained from the natural resource, salt. It can be produced from potassium chloride as a co-product of caustic potash but, with rare exceptions, it is made from salt. Its importance in the national economy is evidenced by the fact that it was the first chemical to be placed under government allocation after World War II was declared. Other than for war purposes, industrial chemicals, and pulp and paper manufacture, it is used in lesser proportions by the textile and rayon industries, in sewage sanitation, in water treatment and, in *very* minor quantities, in oil refining, magnesium production, and flour processing. The War Production Board estimated that the chemical industry's consumption of chlorine rose from less than half of the supply before the war to three fourths during the last of the war and that the paper industry consumption dropped from 33% to 12–13% during the same period (*30*). Before World War I, a considerable amount of chlorine was imported in the form of bleaching powder. A little more was exported during the war years than was imported but, in 1945 and 1946, the imports again were greater. This amount was not enough, however, to affect the price to any extent.

In the pulp and paper industry, chlorine is used chiefly for bleaching the various types of chemical pulps, rags, and waste paper. It is used in minor quantities for bacterial control to prevent slime growth. There are several other bleaching agents used in the pulp industry including sodium chlorite, sodium hydrosulphite, sodium peroxide, and calcium hypochlorite (bleaching powder). According to Lamie (*26*), few pulp companies (approximately 12 companies and 17 mills) make their own caustic soda and chlorine electrolytically. Not very many companies, particularly small ones, find this feasible, since the installation of a chlorine plant requires a capital outlay that could be justified only if a company used a large amount of chlorine and caustic or could sell the surplus at a profitable price. When competition is keen, these plants find it hard to sell profitably. A company contemplating setting up its own electrolytic plant must consider the cost of the plant in relation to the cost of the product delivered at the time and

(continued on page 22 A)

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(continued from page 20 A)

its probable cost for sometime in the future, the convenience of buying the product, the availability and cheapness of electric power, the proximity to a salt deposit, the availability of labor, and the ease with which equipment and finances may be obtained. It would seem that, when the bleaching of kraft pulp becomes more general, mills which bleach 150 tons of pulp or more per day could produce chlorine and sodium sulphide or sulphate with economic advantages. This would be particularly true during times when the normal supply is curtailed. Installations by paper companies in the past have been largely the result of the cutting off of their normal supply.

The U. S. Department of Commerce publishes the census production data on chlorine monthly, but no agency reports data on the consumption by industries. Excluding the government owned and operated plants and the amount made and consumed by the pulp and paper companies for 1933–1939, the data for the production of chlorine in the last twenty years are shown in Table VI.

Table VI. Chlorine Production (1000 Short Tons)

1927	57	1942	990
1929	200	1943	1214
1931	181	1944	1262
1933	217	1945	1192
1935	319	1946	1165
1937	446	1947	1370
1939	514	1948	1621
1941	798[a]		

Source: Bureau of the Census, published in the U. S. Department of Commerce, Industrial Reference Service. Part 2. Chemicals, Drugs and Pharmaceuticals, No. 83 (June, 1946); supplemented by data from the Chemicals and Drugs Section of the U. S. Department of Commerce. 1948 data are from *Chem. Eng.* 56, No. 4: 310 (April, 1949).
[a] From 1941 on chlorine made and consumed by the pulp and paper companies is included.

If the various estimates are correct, the paper industry took nearly half of the total supply at one time. It uses about 16% of the total at the present time, according to estimates. During the recent war, the War Production Board enacted Rule L11 which restricted the brightness of paper and thereby limited the industry's use of chlorine. The war uses took so much of the chlorine supply that the paper industry was able to consume only an estimated 13% of the total. Since the end of the war, both the total supply and the pulp industry's use of chlorine have increased, although just how much of the supply the pulp industry is consuming currently is not known accurately. Estimates have been made from time to time by various people close to the supply (Table VII).

Table VII. Estimated Chlorine Consumption by the Pulp and Paper Industry (1000 Short Tons)

Year	*Amount consumed*	*Percentage of Total Consumption*
1929	70	35
1935	146	46
1937	157	35
1939	160	31
1940	170	27
1941	150	19
1942	163	16
1943	160	13
1944	160	13
1945	175[a]	15
1946	190[a]	16
1947	220[a]	16
1948	225[a]	16

Source: Estimates are for the most part taken from *Chemical Engineering*, especially from the article by Porter, *Chem. Met. Eng.* 52, No. 1: 115 (Jan., 1945).
[a] Estimated on the basis of usage of chlorine as follows: 5% sulphite (bleached) pulp, 10% sulphate pulp; 5% semibleached sulphate pulp, 3% soda, and a nominal amount for water purification and treatment (Lamie (*26*) estimates that pulp bleaching took 21% of the supply in 1940 and 11% at the end of 1947. Talbot (*28*) estimates 28.9% in 1940 and 11.8% in 1944.)

The use-pattern established through allocations by the War Production Board for January 1, 1944 to June 30, 1945 is indicated in Table VIII.

Allocations during the war period did not always correspond with actual consumption but, since no record was kept of actual consumption of chlorine, the degree of discrepancy is not known and the allocation pattern must be accepted as the best estimate for the particular eighteen-month period in which allocations were made. In August, 1945, chlorine was taken off of allocation. Since that time industry has been free to increase its consumption. Early in 1946, because of the lessened war demand, chlorine seemed relatively plentiful, but this situation did not last long. The Interstate Commerce Commission, which regulates the shipping of chlorine, had ruled that chlorine must be shipped in metal cylinders or in tank cars. Inasmuch as these were extremely scarce, the supply situation of chlorine was aggravated. The shortage of chlorine, which started early in 1946, was reflected in the price. Chlorine has been approximately $1.75 per 100 pounds in tank-car lots (freight charges equalized) with some few fluctuations since 1931. It began to rise early in 1946 and, by the summer of 1948, it had reached the level of $2.70 to $3.90 (f.o.b. works). With the increased capacity which is estimated to

(continued on page 24 A)

Table VIII. Allocations of Chlorine—1944–1945

Short Tons, Pure Basis

Uses	*Total*		*Jan. 1–June 30, 1945, tons*	*July 1–Dec. 31, 1944, tons*	*Jan. 1–June 30, 1944, tons*
	Tons	*%*			
Total allocations	2,092,248	100.0	686,908	695,671	709,669
Export	15,480	0.7	1,903	6,022	7,555
Direct military[a]	57,238	2.7	19,839	25,220	12,179
Other uses	2,019,530	96.6	665,166	664,429	689,935
Chemical manufacture	1,544,787	73.8	525,600	508,878	510,309
Paper processing	254,653	12.2	88,071	84,842	81,740
Metallurgical uses	100,179	4.8	6,810	29,018	64,351
Water treatment	62,730	3.0	18,226	21,735	22,769
Synthetic rubber	14,775	0.7	9,645	5,130	0
Food treatment	1,365	0.1	123	113	1,129
Petroleum refining	1,296	0.1	495	330	471
Miscellaneous uses and small orders	39,745	1.9	16,196	14,383	9,166

Source: Bureau of the Census. Industry Division. Facts for Industry Series 6-8-58 (March 20, 1947).
[a] End use data not available.

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CHEMICALS FOR INDUSTRY

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THE RESINOUS PRODUCTS DIVISION

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The Resinous Products Division was formerly The Resinous Products & Chemical Company

(continued from page 22 A)

be in production in 1949, the price should begin to decline.

Specific industrial demands should be reported currently so that those using chlorine may know how much they can expect to obtain and at what probable cost. For security reasons, if not for economic ones, accurate industrial consumption data should be collected periodically by the U. S. Bureau of the Census or some other government agency. Data then would be comparable for establishing secular trends.

SODA ASH

Another salt product used by the pulp and paper industry is soda ash (sodium carbonate). In the recent past, it has been the cheapest form of alkali used by the paper industry. Soda ash is the essential make-up chemical for pulping by the soda and semichemical processes and is used in cooking rags and straw. It is used in the preparation of rosin size, as a water softener, in the deinking of waste papers, and for solubilizing casein.

Soda ash occurs naturally in California (Owens and Searles Lake), but the natural supply ordinarily comprises approximately 5% of the total supply used (*31*), although in September, 1947, the proportion of natural product rose to 7%. Most of the supply is manufactured from common salt by the ammonia process (Solvay soda process). For this reason, the price of ammonia and its scarcity influences the price of soda ash. If ammonia is scarce and the price high, it follows that the cost of making soda ash will also be high. During the war, expansion of soda ash capacity was curtailed and the product was allocated. However, in 1946 and 1947, capacity increased and, by the end of 1948, it exceeded 5 million tons a year. Both the manufactured production and mined product is expected to increase in 1949. Westvaco Chlorine Products Corporation opened a mine in Wyoming in 1949 which has a capacity in excess of 100 tons a day (*31*). It can meet the needs of pulp mills west of Chicago.

Soda ash is used also in the glass (its largest use), soap, nonferrous metals, and chemical industries. When soda ash is less expensive than caustic, the latter can be made from soda ash and lime, although the amount of caustic from this source is declining except in the recovery operations from soda, sulphate, and semichemical pulp manufacture. Soda ash production is reported monthly by the U. S. Department of Commerce (Industry Report on Chemicals and Drugs). From a production level of 2.9 million short tons in 1939, soda ash has jumped to 4.9 million tons in 1948. The distribution of soda ash has been estimated by the market editors of *Chemical Engineering* annually. There are no official census data on the distribution. Estimates for the past 20 years are shown in Table IX.

Table IX. Estimated Soda Ash Consumption

Year	Estimated total consumption, 1000 short tons	Estimated comsumption by pulp and paper industry, 1000 short tons	%
1927	1415	85	6.0
1929	1668	110	6.5
1931	1502	78	5.2
1933	1654	80	4.8
1935	1871	80	4.3
1937	2258	104	4.6
1939	2961	105	3.5
1941	3746	155	4.2
1943	4543	155	3.4
1945	4581	175	3.8
1946	4490	190	4.2
1947	4800	220	4.6
1948	4880	230	4.7

SALT CAKE

Salt cake, as used by the pulp and paper industry, may also be termed a salt product. The first salt cake was made by Glauber by decomposing common salt with sulphuric acid (*39*). Although natural salt cake is frequently used by the pulp industry, the product most in use results as a byproduct from the production of hydrochloric or muriatic acid. Niter cake, which is produced in minor amounts by plants making nitric acid from sodium nitrate and sulphuric acid, can also be used. There are many sources of salt cake: the natural product, the byproduct from hydrochloric acid, synthetic salt cake (*38*), chrome salt cake, and other byproduct salts from the chemical industry. Glauber's salt differs from anhydrous sodium sulphate by 10 molecules of water and is not used by most of the pulp mills when salt cake is available because they do not have the equipment to handle the difficulties arising from the extra amount of water in the salt. The producers of sulphate wood pulp are extremely dependent upon salt cake and, when enough salt cake is not available, they must draw on the supply of other types of sodium sulphate for their efficient operations.

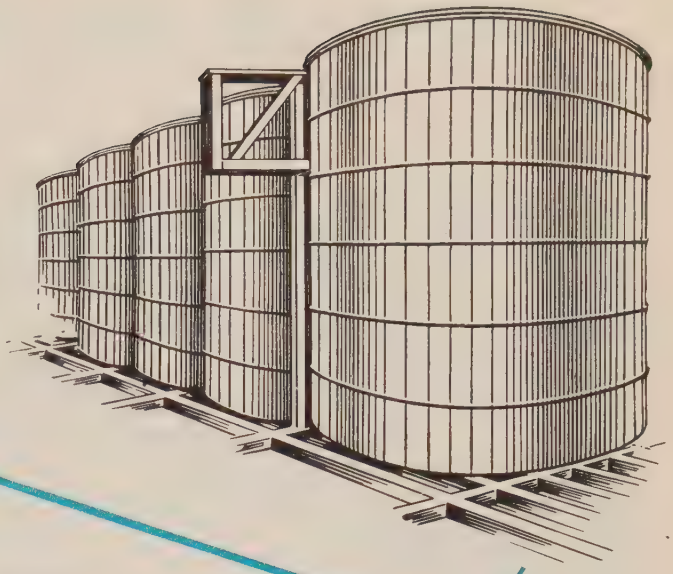
The various sources of salt cake were adequate to meet the increased use of the growing kraft industry during the late thirties, although the industry took larger proportions of the supply each year. Both anhydrous sodium sulphate and Glauber's salt are ordinarily used in the production of materials other than paper but, in the postwar years and until early 1949, the supply of salt cake was not sufficient to meet the needs of the kraft industry and it had to make its own substitutes, using synthetic materials or Glauber's salt. The glass industry, a large user of salt cake, has in recent years turned to salt more than to salt cake in crude form. These materials are also used in the chemical and textile industries, in freezing mixtures, in medicines, and as a stock feed. A small amount of sodium sulphate goes into ceramics, and detergents have only recently become a consumer, using salt cake as a diluent.

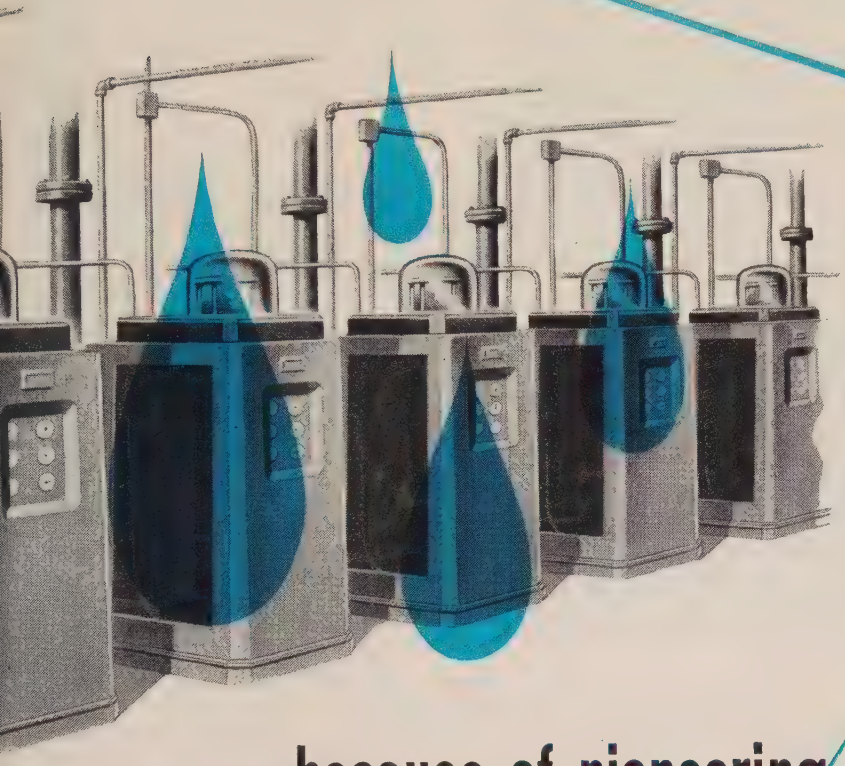
The amount of salt cake or its equivalent in some form of sodium sulphate used by the kraft pulp industry varies from 150 to 450 pounds per ton of pulp. The wide range is accounted for by the improvements which have been made in recovery processes. With the increased installations of precipitators in the newer pulp mills (*37*), the amount of salt cake necessary for a ton of kraft pulp has decreased. Before the war, the average was considered to be about 360 pounds. During the war, it was closer to 250–275 pounds and for the last few years it has probably been around 250 pounds. Although there are other uses of salt cake in the pulp and paper industry, the production of kraft pulp has provided the industry with

(continued on page 26 A)

as you were in 1900

Effective methods of purifying water supplies were virtually unknown at the turn of the century, as was efficiency in other fields such as textiles, paper, glass and soap-making





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In 1900 practically no community was protected effectively against water-borne diseases. Today, every modern city and town is safeguarded by scientifically planned and operated water purification systems and sewage treatment plants.

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(continued from page 24 A)

the base for its estimates of salt cake. The estimated consumption of salt cake as related to the capacity and production of sulphate pulp is presented in Fig. 4.

Exactly what proportion of the total supply the industry takes, of course, depends upon the definition of supply. The Minerals Yearbook each year carries data on the amount of crude salt cake which is mined. The U. S. Department of Commerce (Industry Report on Chemicals and Drugs) indicates the amount of inorganic chemicals produced either as byproducts or synthetically. To obtain a complete picture of supply (at least during a short supply period), we must include the mined and produced salt cake, imports, Glauber's salt, and anhydrous sodium sulphate, even though the last two are not substitutes in the pulp and paper industry except when the supply of salt cake is especially scarce.

The estimated tonnages of salt cake consumed by the pulp industry, taken from *Chemical Engineering*, are given in Table X (see also Table XII).

Table X. Estimated Consumption of Salt Cake by the Sulphate Pulp Industry (1000 Short Tons)

1927	90[a]	1938	336
1928	116	1939	407
1929	138	1940	512
1930	143	1941	604
1931	137	1942	650
1932	154	1943	583
1933	189	1944	625
1934	187	1945	615
1935	225[a]	1946	630
1936	248	1947	650[b]
1937	294	1948	750[b]

[a] The U. S. Tariff Commission estimated 106,000 and 217,000 for 1927 and 1935 (Report No. 124, 1937).
[b] Estimated by The Institute of Paper Chemistry.

Before the war the sulphate pulp industry depended greatly upon imports to make up the needed supply of salt cake. Total imports (largely German—76% in 1935 and 81% in 1936) amounted to about one-third of the United States salt cake supply. Imports including small quantities of anhydrous sodium sulphate and Glauber's salts were reported for 1933 through 1945 by the U. S. Department of Commerce (*41*) and are given in Table XI.

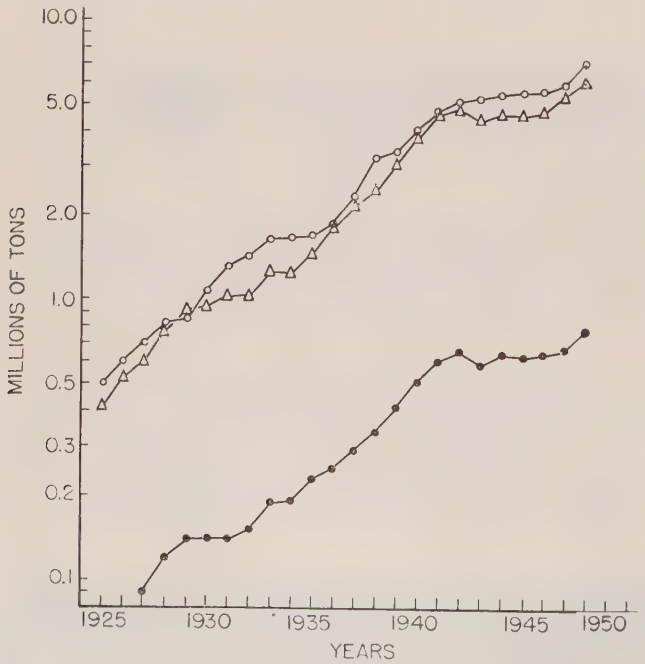

Fig. 4. Salt cake consumption vs. sulphate pulp capacity and production

○—Total sulphate pulp capacity, Δ—Total sulphate pulp production, and ●—Estimated salt cake consumption

Table XI. Imports of Salt Cake (1000 Short Tons)

1933	110	1941	76
1934	99	1942	94
1935	117	1943	33
1936	163	1944	31
1937	237	1945	20
1938	150	1946	22.5
1939	155	1947	44
1940	73	1948	26

By 1940, only 73,000 tons of salt cake came into this country. Over half came from the United Kingdom and Canada. Belgium provided the largest amount from any European country. Germany's contribution had declined to a mere 2200 tons that year.

The government-owned Saskatchewan Minerals Plant at Lake Chaplin commenced production of salt cake and Glauber's salt in 1947 which aided the southern kraft pulp mills. However, Canada imported from us almost as much salt cake and Glauber's salt as she sent to us in 1945. For example, she sent 17,564 tons of sodium sulphate to us and imported 14,551 tons of salt cake and Glauber's salt (*41*). Net imports have increased since then. The West Coast pulp mills have never depended upon imports. They obtain their salt cake from the natural deposits at Searles Lake.

Companies producing salt cake are in the south central or western part of the United States. In 1933, the American Potash & Chemical Corporation began to mine salt cake at Trona in the Searles Lake Region. In the latter part of the thirties, several companies began to mine it—the Ozark Chemical Company at Monahaus, Texas; the Sodium Products Company at Wilson Creek, Grant County, Washington; the Salt Lake Sodium Production Company at Saltair mined Glauber's salt and anhydrous sodium sulphate; some Glauber's salt was produced near Casper, Wyoming; and the Iowa Soda Products Company mined Glauber's salt at Rawlins, Wyoming (*40*).

A large deposit in western North Dakota is controlled by the Ozark-Mahoning Company of Tulsa. In northern Divide County, North Dakota, the Sodium

Table XII

Year	*Total sodium sulphate supply,[a] 1000 short tons*	*Estimated amount used by pulp industry 1000 short tons*	*%*	*Supply of salt cake (domestic plus imports), 1000 short tons*
1941	827	604	73	607
1942	936	650	70	665
1943	880	583	66	598
1944	890	625	70	596
1945	842	615	73	563
1946	825	630	76	552
1947	960	650	65	671
1948	1006	750	75	682

Source: See reference *41* for supply data. Other figures were prepared therefrom by The Institute of Paper Chemistry.
[a] Includes Bureau of Census classification: sodium sulphate (anhydrous), Glauber's salt, and salt cake.

(continued on page 28 A)

5 Great NEW Values

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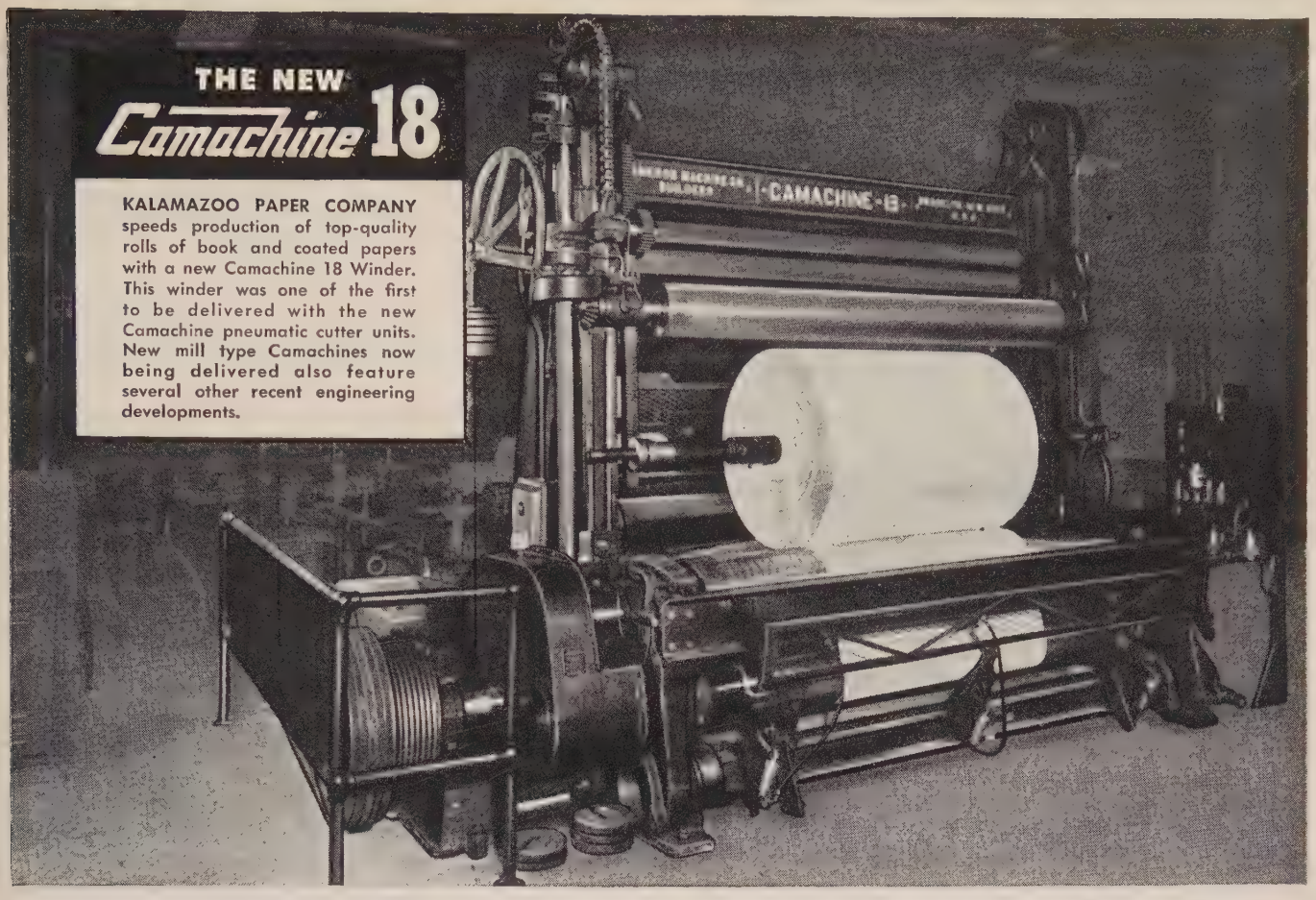
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***NEW!* PNEUMATIC BRAKE ON DRIVE AND IDLER ROLL.** A simple one-hand control brings the fastest, heaviest winder to a s-m-o-o-t-h, quick stop, by braking the drive roll *and* the idler roll simultaneously. This new brake corrects one of the most serious danger spots in big winder operation. Standard on all new mill-type Camachines.

***NEW!* MOTOR-DRIVEN ROLL EJECTOR.** Automatic power—to move the heaviest rolls swiftly and safely to unloading position. So gentle that not a single layer of paper can be damaged. Operates with no more effort than ringing a doorbell. Standard on Camachines 20, 19 and 18; optional on Type 14.

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(continued from page 26 A)

Corporation of Chicago controls five major deposits, which are now under development. Some Glauber's salt from the recrystallization reservoirs have already been shipped but the anhydrous salt cake and a detergent grade of sodium sulphate will not be on the market before the end of 1949.

The production of salt cake (mined or produced), of Glauber's salt, and of anhydrous sodium sulphate and the percentage of that supply (production plus imports) used by the sulphate pulp industry are listed in Table XII. These data show that the supply of salt cake alone has not been sufficient in recent years to fill the estimated needs of the sulphate mills, let alone the other demands. The lack of supply has been compensated for by the use of substitutes for salt cake or by the use of Glauber's salts or anhydrous sodium sulphate.

The shortage of salt cake began in 1940 with the decline in imports. To make up for this loss, several chemical companies began to produce it from various brines. Both the Arizona Chemical Company and the Desert Chemical Company extracted it from salt brines for the first time (*40*). One chemical company made it synthetically (*38*) and, although the process was patented, it could be duplicated well enough by the kraft pulp mills by mixing 3 parts of sulphur with 10 parts of soda ash. Other mills made a substitute product out of gypsum and soda ash which served as a temporary expedient in kraft pulping, but soda ash also was scarce. Various ideas of producing salt cake were tried but none of them was perfected enough to be put into production and thus relieve the shortage to any appreciable extent (*34*).

The scarce salt cake supply forced the price up to between $25 and $28 a ton, but now that the supply is again plentiful, the price is declining. The prewar price ranged from $13 to $15 a ton, a rate set by imports of a byproduct which had little value and which was delivered to the pulp mills at a very low ocean freight rate. This source was lost during the war and is not likely to affect the domestic markets for a long time to come. The scarcity of salt cake prompted the government-owned plant in Saskatchewan to ship sodium sulphate to this country under terms of a five-year contract; the price, at the time the contract was made, was enough lower than the byproduct to tempt some southern kraft mills, despite the possible uncertainties of shipping at a continuing high freight rate. As long as the cost of producing muriatic acid remains high, the Canadian natural product will undoubtedly be able to compete favorably with the byproduct, sodium sulphate, even with high transportation costs. The freight rates established by the Sodium Corporation for its North Dakota operation are at present below those of Saskatchewan natural salt cake for the Wisconsin, Michigan, and southern markets. If the present market situation prevails, the added supply of salt cake from North Dakota should depress the price further.

Whether the American requirements of the kraft industry, which will increase in the long-time trend, will be met from natural, synthetic, or byproduct sources will, of course, depend upon cost-price relationships. If prices should drop very much, it is possible that the Saskatchewan government may allow taxes or other specific government projects to carry the loss on its sodium sulphate operations in order to keep a certain proportion of its United States market with which neither the private operators of the natural deposits or the manufacturers of the byproduct, even with more efficient operation, could satisfactorily compete. The North Dakota operators will be limited by high transportation costs; the byproduct suppliers will be limited probably by high labor and fixed charges. Neither American source could compete very long with the government monopoly to the north if it wanted to keep the United States market badly enough to engage in a price war any more than American producers could compete with the German byproduct before the last World War.

There is probably no field of statistical inquiry more important for the pulp and paper industry than that of salt cake in view of the growing importance of sulphate pulp, yet accurate consumption data, which would indicate trends, are not available.

LIMESTONE

Limestone, either in the mined form or as lime, is the oldest chemical raw material used by the paper industry. Much of that consumed by industry today is used as a cooking liquor in the sulphite process, where a high calcium lime containing very little magnesia is used. The cooking liquor is produced by the chemical reaction between sulphur dioxide and lime (*45*). A high magnesium or dolomitic lime is preferred in the milk-of-lime method of sulphite pulping. Most sulphite mills, however, use the Jenssen tower system whereby limestone is used rather than lime. Quicklime is used in cooking rags and straw, dolomitic lime being preferred. Lime is used for making calcium hypochlorite used in bleaching. Some hydrated lime is used for softening and purifying water, and as an emergency supply in storage, inasmuch as quicklime does not store well. It air slakes and eventually becomes useless for most purposes. Its transporation, therefore, is a packaging problem. It must be packaged in airproof and moistureproof bags or steel drums; the former are gaining in usage. Lime is used to convert soda to caustic in the soda and sulphate processes. It is also used in the utilization of sulphite waste liquor.

Of all the industrial users of limestone, either as the stone or as lime, the paper industry ranks fourth, according to the Bureau of Mines (*45*). Even that amount is small and represented only 2.8% of the total industrial uses in 1945, or 1,375,000 tons out of a total of 49 million. Moreover, the chemical and processing industries consume only about a third of the total supply of limestone. The biggest uses are, of course, the nonindustrial ones, such as concrete and other road material, cement manufacture, railroad ballast, liming the land, harbor work, building stone, etc. Among the industrial uses, metallurgical uses (flux) in 1945 took 62.4% of the total; production of alkalies took 14% and refractory 7%. Calcium carbide and cyanamide took 2.6%, an amount almost equal to that used by the paper industry. All but two other industrial uses took less than 1% and

(continued on page 30 A)

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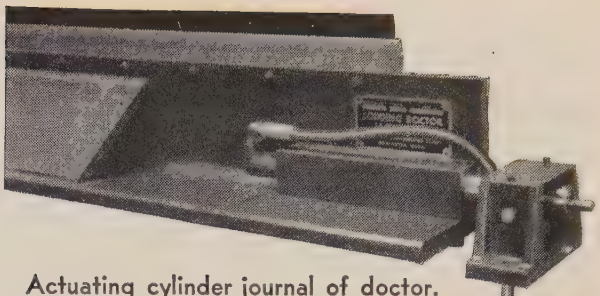
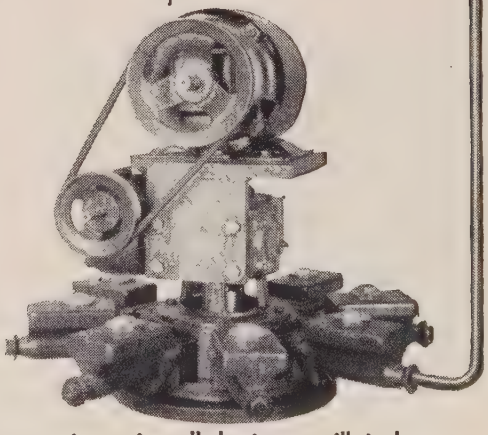


Actuating cylinder journal of doctor.
Note small space requirement.

The Lodding system offers low initial cost, low installation cost, low maintenance cost. This, plus the fact that it will fit anywhere a doctor will fit, including a great many places where oscillation has long been thought impossible, makes the Lodding Hydraulic Oscillating System the complete answer to the doctor oscillating problem.



Master unit serving all doctors oscillated.
No valves—no circulating system.

Lodding Engineering Corporation, Worcester, Mass.
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Table XIII. Limestone Production and Its Consumption by the Paper Industry as Stone or Its Equivalent in Lime

Year	Total production (sold or used by producers) (all uses)	Consumed as stone and lime (includes bleach)[a] (1000 short tons)	%	Consumed as stone	Consumed as lime	Total lime, %
1921	75,800 (est.)	592	0.8	120	236	9.0
1922	96,427	770	0.7	149	310	8.5
1923	119,775	829	0.7	207	311	7.7
1924	122,001	738	0.6	138	300	7.3
1925	135,761	863	0.6	110	377	8.2
1926	142,983	1049	0.7	202	423	9.3
1927	152,687	1148	0.7	289	430	9.7
1928	150,797	1013	0.7	155	430	9.6
1929	152,839	1095	0.7	274	411	9.6
1930	136,362	1006	0.7	249	379	9.6
1931	103,907	768	0.7	194	287	10.6
1932	70,314	672	0.9	153	260	13.2
1933	66,489	806	1.2	196	305	13.4
1934	82,032	850	1.0	262	294	12.3
1935	83,411	877	1.0	188	344.5	11.5
1936	123,886	1050	0.8	230	397	10.6
1937	132,374	1218	0.9	323	448	10.9
1938	114,391	1027	0.9	223	402	12.0
1939	139,818	1231	0.9	303	464	10.9
1940	156,473	1467	0.9	334	567	11.6
1941	188,058	1716	0.9	362	677	11.1
1942	202,353	1648	0.8	435	606	11.1
1943	178,040	1472	0.8	385	543	8.2
1944	152,601	1440	0.9	375	532	8.2
1945	151,747	1375	0.9	353	511	8.6
1946	190,579	1518	0.87	386	566	9.4
1947	213,497	1861	0.85	570	646	9.5

Source: Mineral Resources, 1921–1932; Minerals Yearbooks from 1932 on. See reference *45* for all data on limestone and its equivalent in lime.
[a] Limestone equivalent of lime is calculated by multiplying the quantity of lime by 2.

(continued from page 28 A)

most of them took less than 0.1%. The consumption by the paper industry of limestone and its equivalent of lime (at a two to one conversion ratio) is indicated in Table XIII.

The amount of lime used in the industry depends greatly upon the system in each mill for recovering it. Those mills with good recovery systems reuse it continuously. Inasmuch as the tendency is toward the installation of more recovery systems, the use per ton of pulp is declining.

Limestone is readily available to the paper mills in all parts of the United States. It is quarried for the Pacific Coast mills in Washington and Oregon; for the New England States in Maine and Vermont; for the Lake States in Wisconsin, Ohio, and Michigan; for the central states in Ohio, Indiana, Illinois, Iowa, Missouri, and Oklahoma; for the Middle Atlantic States in Pennsylvania and Virginia; and for the southern states in Texas and Tennessee. Lime is produced in most of these states, the largest sales being in Alabama, Pennsylvania, Tennessee, Michigan, Ohio, and Minnesota. When shortages occur, as they did during the war and the postwar period, they were the result of the difficulties in getting labor and materials. Moreover, there was an increased demand because of the high level of postwar paper production. Transportation shortages have also affected the supply of lime. More data are available on lime than most of the other nonfibrous raw materials used by pulp-paper producers because the Bureau of Mines collects data on both the supply and industry usage, although the supply is defined as the reported tons sold or used by producers. The paper industry should not have any difficulty in obtaining this material indefinitely.

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SULPHUR

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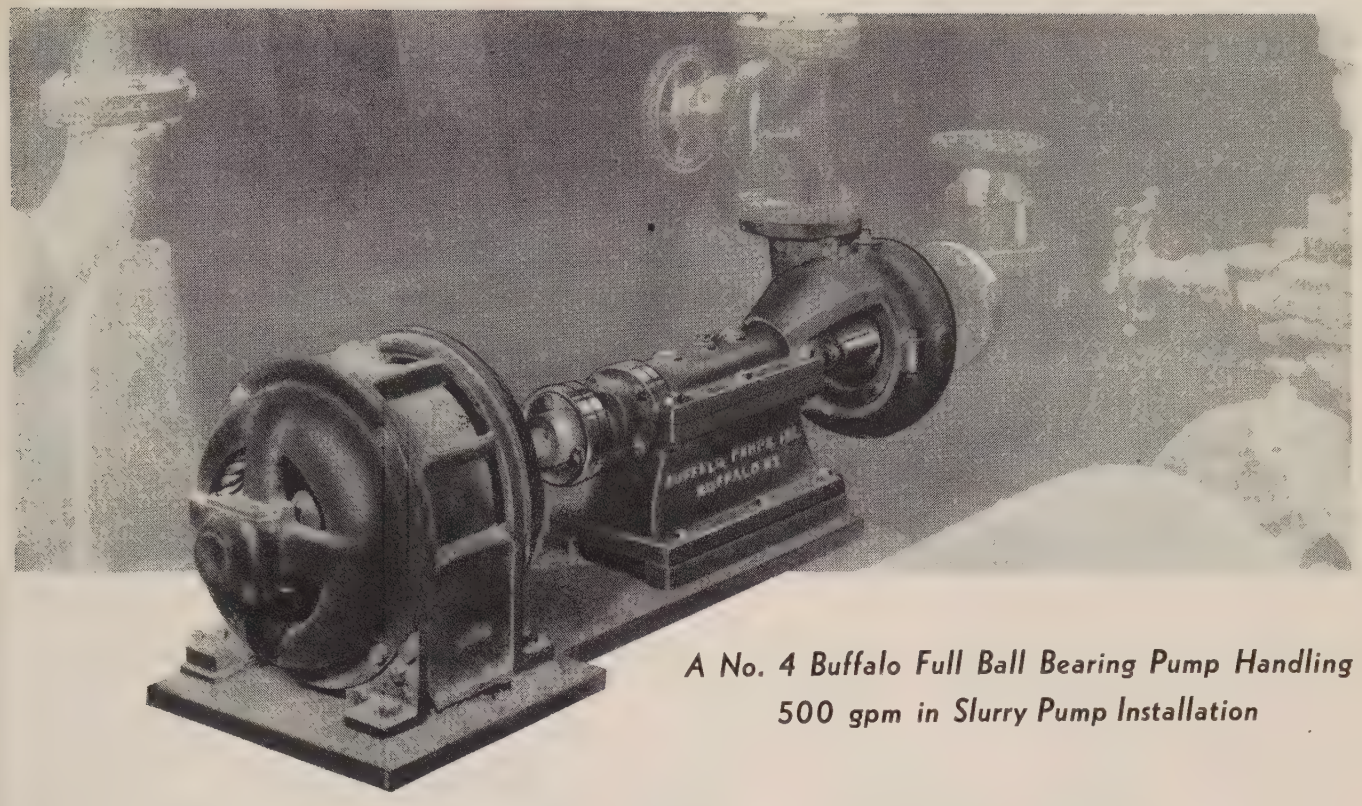
(continued on page 32 A)



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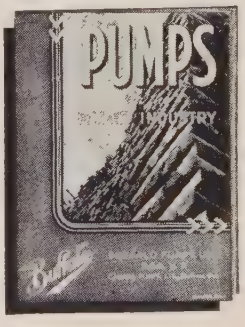

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(continued from page 30 A)

SODIUM HYDROXIDE (CAUSTIC SODA)

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Received July 1, 1949.
Acknowledgment. The author is indebted to her colleagues of the Institute for their advice and criticisms.

The Paper Industry—A Stable and Growing Coal Market

Ed.: The following bulletin was recently issued to its members by Appalachian Coals, Inc., the world's largest coal marketing agency, Cincinnati, Ohio. J. E. Tobey, President, is a member of TAPPI and was one of the speakers at the Second Engineering Conference of the Pulp and Paper Industry held at Philadelphia in 1947.

The paper industry appears to have halted its eight-month decline from the postwar peak established in November of 1948. Indications strongly suggest that July was the low month in production, and that the August production, sharply up following vacation shutdowns, will approximate the 1,700,000 tons turned out in March of this year.

Further cause for satisfaction with recent trends in the paper industry is found in the steady rise in the operating rate since the week ended July 16. Following a virtually unbroken six-month decline, paper production has moved steadily upward from 76.3% of capacity operations in the week ended July 16 to reach 89.8% of capacity in the week of August 20. At the same time, paperboard output climbed from 64% of capacity to 84%. In total tons produced, paperboard production in the week ended August 20, for the first time this year, was well above that of a year ago. The basic demand for paper has been above current production since February of this year.

The upturn has provided a pleasant surprise for even the industry's leaders, who report that business is coming in even stronger now than it was a month ago, and that operating rates are destined to move still further toward full capacity. Said one paper executive, "This increase is no flash in the pan."

The strong buying trend which has developed in a move to build up depleted inventories suggests a reversal in the downward price trend which got under way in January of this year. According to the *Journal of Commerce* Index, prices have carried from 195.7 to 175.4 at the middle of August.

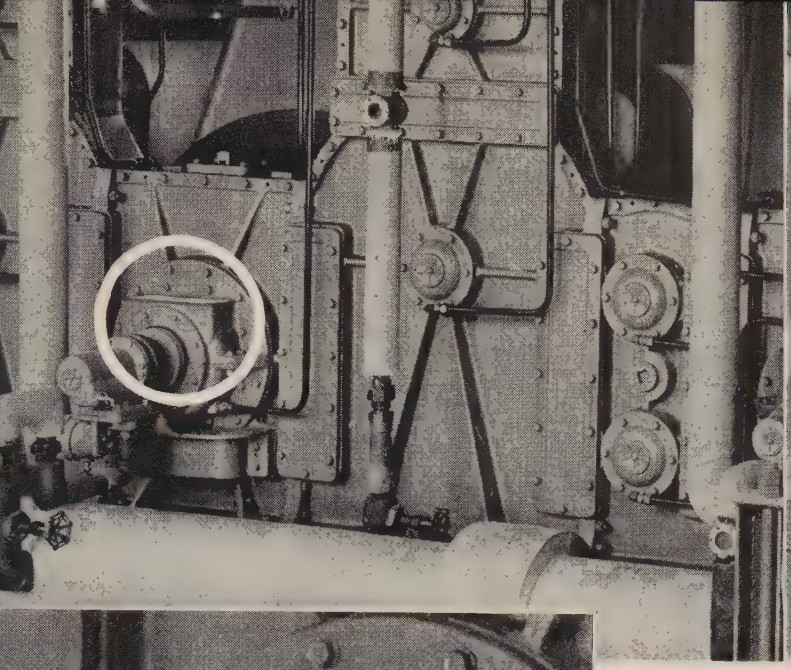
Usually reliable industry estimates place total 1949 paper consumption in the U. S. at around 24,000,000 tons. Production of around 20,000,000 tons plus imports will account for the supply. For production to reach 20,000,000 tons this year, it must average 1,820,000 tons per month for the balance of the year, or 15% above the average output rate reached in the first eight months of the year.

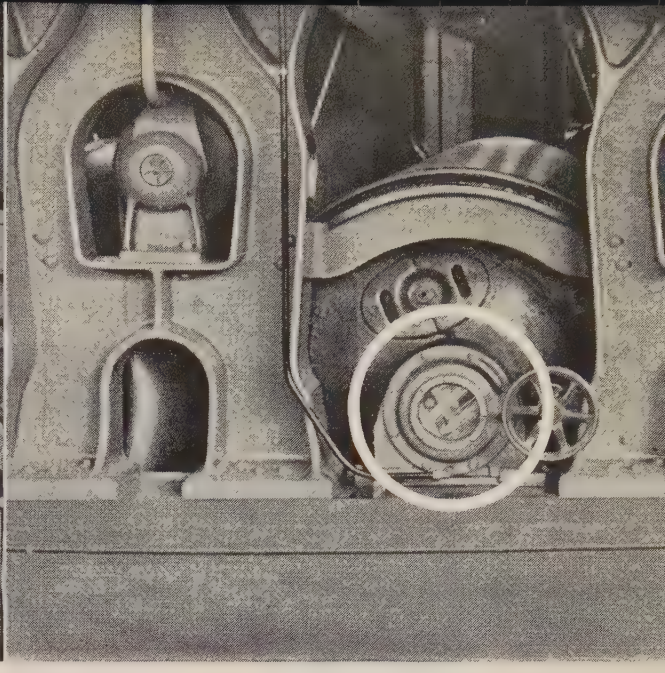
This is good news for the coal industry. Under the generally-accepted formula of one ton of coal to one ton of paper, and with well over 80% of the mills using coal as their source of energy, the paper industry provides a substantial and stable coal market.

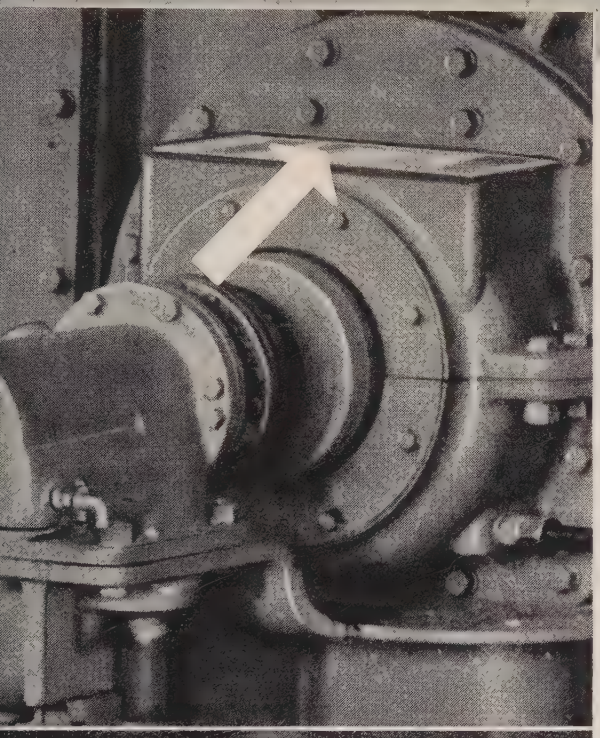
The expanding paper industry in the past 20 years has been characterized by a phenomenal growth in the South. According to industry figures, the percentage increase in the South since 1929 has amounted to between 500 and 600%. The South now accounts for 26% of all production. The growth in capacity in New Zealand, the oldest of the papermaking regions, has been 11% in the past 20 years. New paper mills have grown up on the West Coast, while major capacity centers around the Great Lakes.

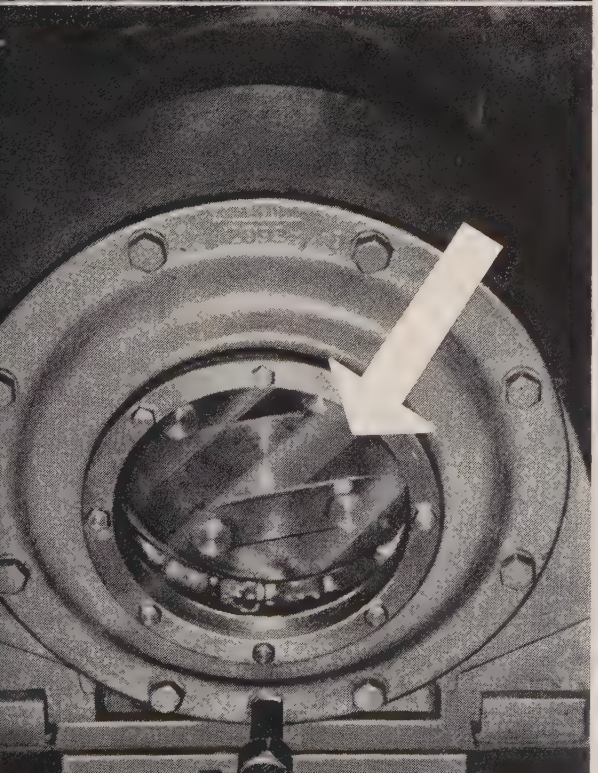
Following World War II, the pulp and paper industry engaged in a huge program of expansion ranking only second to the electric-utility industry in the purchase of steam-generating equipment. This was the most recent phase in a steadily-increasing per capita output in the paper industry, which has seen production rise from 3,000,000 tons in 1900 to 22,000,000 tons last year. Today the average citizen in this country consumes more than 350 pounds of paper in a year—about twice as much paper as meat. Spectacular success has accompanied the industry's efforts in introducing the multiwall bag, the insulated "jiffy bag," and its entry into the plastics field, to name only a few recent developments. Paper has been truly called the repository of our civilization.

The future of this thriving and virile industry points to an ever larger output as its products move into new fields. New uses and continuous research, plus the further exploitation of present markets, should make for growth over the next few years outstripping average industrial production by a goodly margin.









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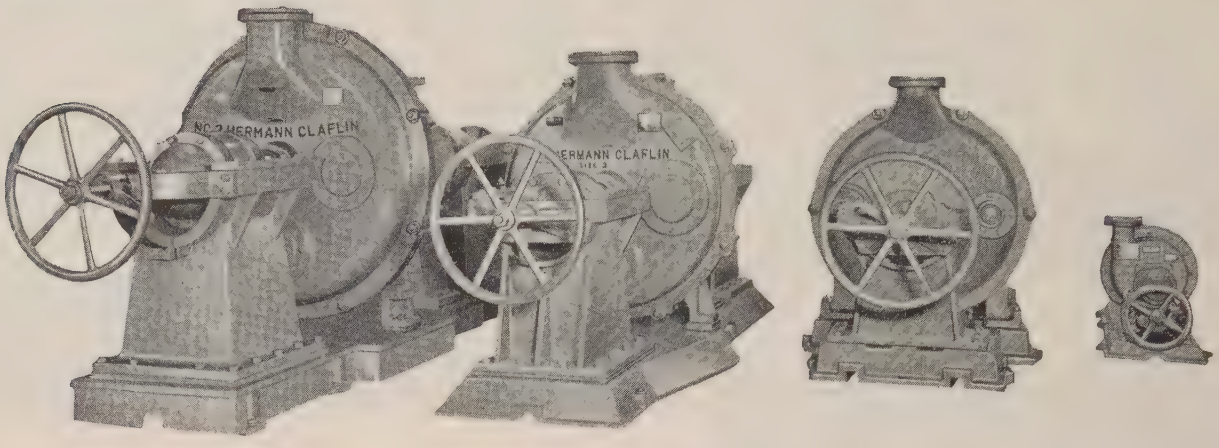

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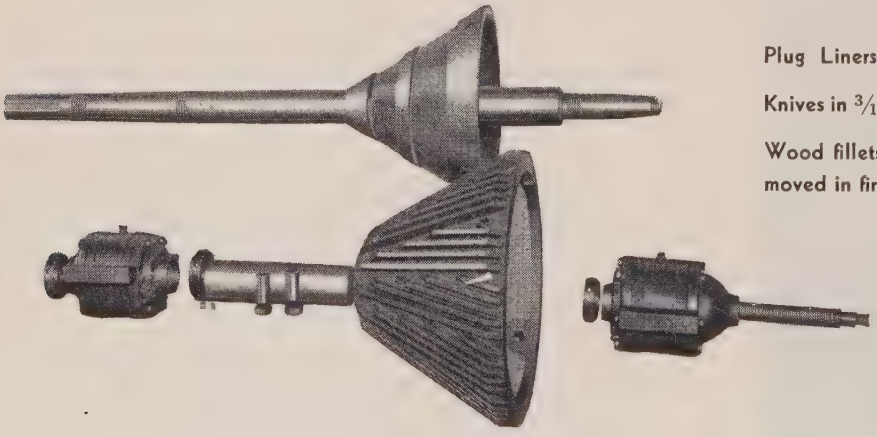

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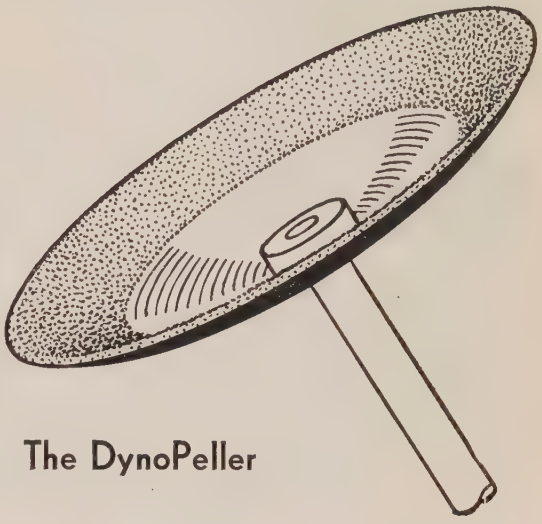
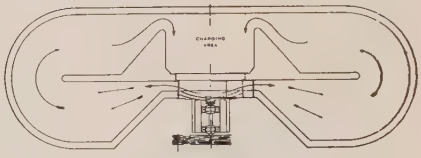
There are four types of DynoMachines for either batch or continuous operation. Let us tell you how these machines make better pulp from a given grade of stock and make it at less cost. Write for further information.



The DynoPeller



The DynoChest

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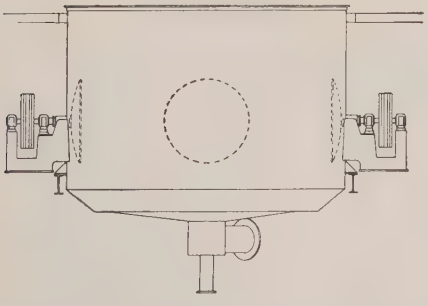
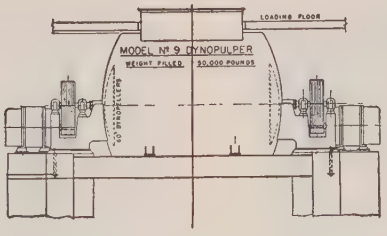


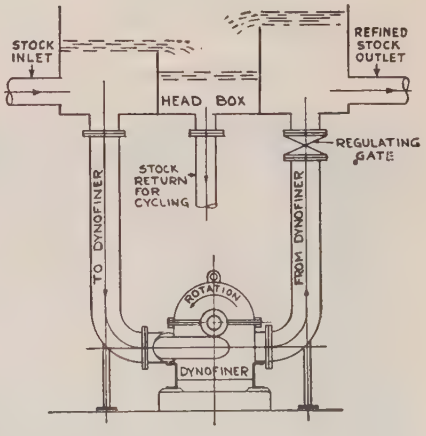
The QuatroPulper

. . . is composed of a vertical circular vat, open at the top for charging and equipped with four DynoPellers. Primarily designed for large capacities. Stock may be charged all at once. Used for either batch or continuous operation.



The DynoPulper

. . . is composed of a horizontal circular vat with charging area at its top and equipped with two DynoPellers. Stock charged all at one time. Used for either batch or continuous operation. Available also in laboratory sizes.



The DynoFiner

. . . is equipped with either four or six small DynoPellers. It is used in a continuous operation and completely separates fiber bundles from slush stock.

Fourth Engineering Conference

George H. Pringle, General Chairman TAPPI Engineering Division

The Fourth Engineering Conference of the Pulp and Paper Industry sponsored by the Technical Association of the Pulp and Paper Industry was held at the Statler Hotel, Boston, Mass., October 31 to November 3, 1949. About 500 engineers attended.

Meetings of, October 31

The meeting was opened by George H. Pringle of the Mead Corp., Chillicothe, Ohio, who is General Chairman of the Engineering Division. He introduced A. E. Bachman, Missisquoi Corp., Sheldon Springs, Vt., President of the Technical Association, who welcomed the group to this conference. The session was then turned over to the Mill Design and Economic Aspects Committee, Alvin H. Johnson, Alvin H. Johnson & Co., New York, N. Y., Chairman. The first formal paper was presented by M. C. Celli of the Rust Engineering Co., Pittsburgh, Pa. In his paper, "Modern Paper Mill Buildings," Mr. Celli indicated that paper mill buildings are no longer simple enclosures of space—in order to develop the utmost potential in production, they must provide the best physical environment for each machine and for each individual. An examination of the components to the design of buildings must provide this environment—the structural frame, the walls, the roof, the acoustics, the lighting, the use of color, and the internal atmosphere. There is new emphasis for better employee facilities. An analysis was given of floors and the floor drainage problems with remarks on the corrosion of concrete and masonry caused by fumes and solutions. A study of a semiopen recovery building was presented. Suggestions were made for saving some maintenance costs on buildings with plates detailing eight typical wall sections and eight roof sections, together with a structural and functional analysis of each.

The paper was illustrated with slides of excellent examples of good contemporary architecture of pulp and paper mills in the United States, Canada, and Finland. It is becoming evident that current advances in design, great as they are, are only the beginning.

Following Mr. Celli, Roland A. Packard of the Holyoke Machine Co., Holyoke, Mass., presented "Selection of Paper Machine Drives," A brief description was given of the paper machine of one hundred years ago. In those early days it was recognized that constant speed was of the greatest importance, but papermakers, could not obtain it. Three so-called "rates of motion" were sufficient—high, medium, and low. In order to minimize the "great quantities of paper destroyed" due to uneven and changeable speeds required of the different sections of the machine, pieces of felt properly smeared with lagging wax were either applied or torn off. The Marshall train was introduced in 1910. It was heralded as a boon to the papermakers, and it made it possible to double machine speeds. When these speeds attained 600 f.p.m. the increased power demand took its toll on roughening up the wooden teeth on bevel gears, which action developed vibration transmitted to horn couplings, thence to rolls and machine frames. This condition spurred the engineer toward greater improvement in drives. At this time the V-belt made its appearance in power transmission so that short center application made it adaptable for drives. The hydraulic drive together with the hypoid and spherical bevel gears made their debut with the flat-belt cone-pulley combination. Descriptions were given of each together with relative merits. Machine widths, speeds, and horsepowers again began to tax the engineer's ingenuity, which brought out the individual motor on each section of the machine. This was a d.c. unit connected to a synchronous motor. All these motors were tied together electrically. Next came the synchronous regulators followed by amplified electronic systems of control. The development of yardsticks for the mill engineer was shown with a series of graphs relative to speed ranges for different groups of papers and a general selective guide for type of machine drive. The approximate cost per horsepower for different types of drive was given, together with the outstanding features of each type of drive. A number of illustrations and diagrams completed the talk.

At the conclusion of this last paper, Henry J. Perry, consultant, New York, N. Y., Chairman of the TAPPI Data Sheet Committee, discussed plans for supplementing the data sheet service.

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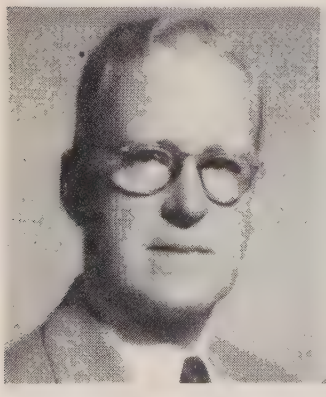


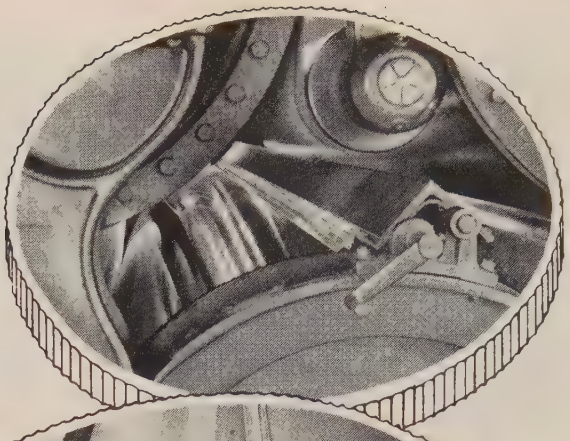
Alvin H. Johnson, Chairman, Mill Design and Engineering Aspects Committee

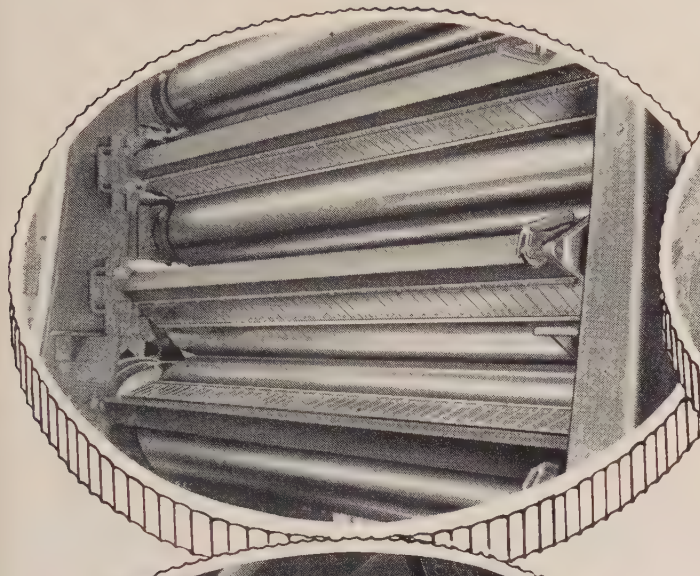
Phillip H. Goldsmith, Chairman, Engineering Research and Machine Design Committee

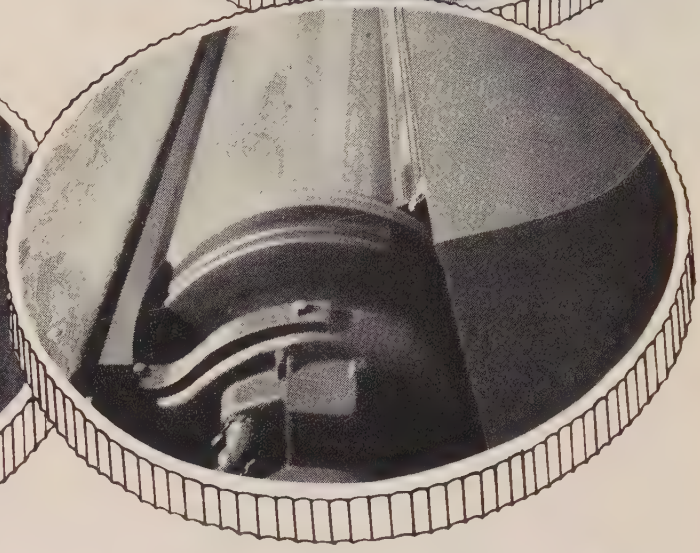
George R. Wadleigh, Chairman, Materials Handling Committee

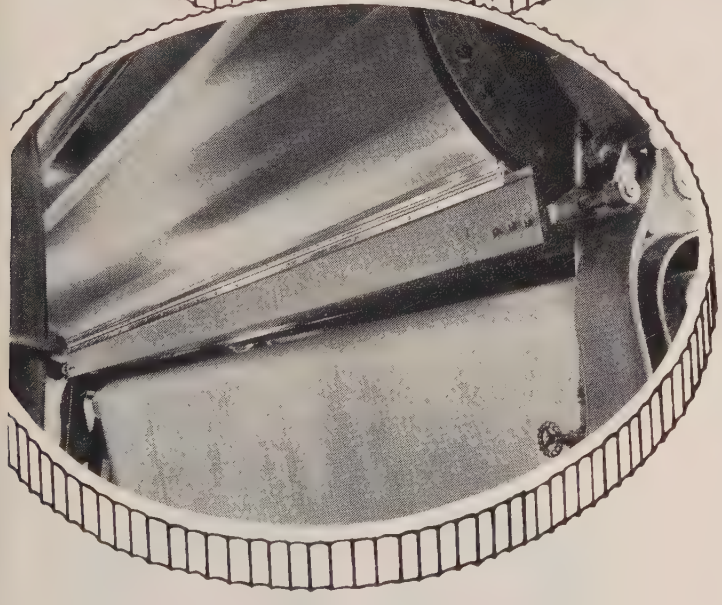
Charles J. Sibler, Chairman, Steam and Power Committee

Minor Expenditure









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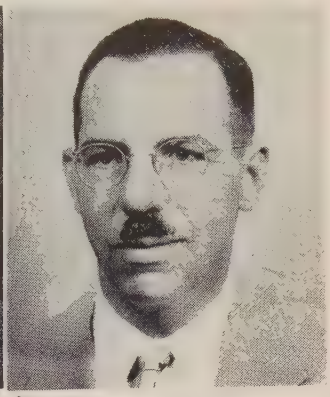
(continued from page 38 A)

Kenneth J. Mackenzie, Chairman, Hydraulics Committee



William McIntosh, Jr., Chairman, Mill Maintenance and Materials Committee

In the afternoon the Engineering Research and Machine Design Committee and the Materials Handling Committee had their sessions. P. H. Goldsmith of the Pusey & Jones Corp., Wilmington, Del., chairman of the first committee, introduced George H. Spencer of the Torrington Co., Torrington, Conn. Mr. Spencer's paper, "Suggested Standardization of Spherical Bearings on the Wet End and Drier Sections of Paper Machines," introduced a proposed basis for the standardization of the primary bearings on both fourdrinier and cylinder machines. The machine widths were divided into three groups: 100 to 139 inches, 140 to 179 inches, and 180 to 240 inches. The speed groupings were: up to 800 f.p.m., 800 to 1500 f.p.m., and 1500 to 2000 f.p.m. Tables were presented to cover the wet section, press section, and drier section of both fourdrinier and cylinder machines as well as Yankee driers and pressure rolls. It was suggested that the adoption of these standards would greatly assist both the machine designers and the mill operators. Mention was also made of the various types of roller bearings now in use.

E. A. Crawford followed and presented "Beta-Ray Basis Weight Gage" prepared by himself and M. Strain, both of whom are with the Continental Paper Co., Ridgefield Park, N. J. He described a new recording indicator for the continuous measurement of the basis weight of paperboard. The device consists of a radioactive source and a recorder. Beta rays are used because they are less hazardous to health and provide a steady source of energy. No Geiger tubes are required. The unit is mounted on the machine after the calender stack to measure paperboard continuously, and the recorder can be so adjusted that light will appear when the weight tolerance is exceeded.

The meeting was then turned over to George R. Wadleigh, Consulting Engineer, Hastings-on-Hudson, N. Y., who is Chairman of the Materials Handling Committee. At this session a paper was presented by S. L. Foster of the Kalamazoo Vegetable Parchment Co., Kalamazoo, Mich., on "Conveyors in Pulp and Paper Mills." This paper was devoted to a description of the materials handling facilities of the new KVP plant at Espanola, Ontario, and descriptions were given of the wood handling facilities both in the woods and at the mill. Pulpwood is cut and stacked into piles along strip roads. In the winter a special tractor with a fork picks up the pile and loads it on a sled rack. The sleds are then made up into trains of ten or more and hauled to either the river of railroad for transportation to the mill. At the mill, the wood is held in a pond from which it is moved into the mill by a haul-out which transports it to a slasher. Belt conveyors have been used for 4-foot wood. They have some advantage over link conveyors in that they have enough elasticity to absorb the shock of falling wood without damage. Less power is required for the drive and because the belt slides under the wood, there is no danger of damage caused by jamming of the wood in the trough. A weightometer is used to record the digester charge.

Salt cake and lime are handled by a vacuum system by which one man can unload a car in three or four hours. Lime from the kiln is transported in a specially constructed screw conveyor that is water cooled.

No reserve of coal is held at the mill. The coal is delivered in hopper bottom cars and unloaded directly into the coal bunker.

Practically all baled and lap pulp are handled with trucks. The paper handling system is an overhead tram rail which picks up rolls of paper at the paper machine winders and delivers them to storage, finishing, or shipping areas. A few trucks are used to handle rolls.

Mr. Foster mentioned, in conclusion, that the materials handling equipment should be so arranged as to eliminate the need of extra work and also that whenever possible mechanical means should be used.

Meetings of Tuesday, November 1

On Tuesday morning November 1, the Chairman of the Steam and Power Committee, Charles J. Sibler of the West Virginia Pulp & Paper Co., New York, N. Y. introduced E. K. Dean of the Foster-Wheeler Corp., New York, N. Y. In his paper, "Recovery of Waste Heat in Pulp and Paper Mills," Mr. Dean discussed the possibilities of recovering heat from digester blow steam. There are four systems which have been used successfully by sulphate and soda pulp mills, namely: direct contact, surface condenser, liquid to liquid, and vapor to liquid. The advantages and disadvantages of these systems were given. Another source of possible recovery of heat is from digester relief steam either by condensing the steam in an accumulator for heating a liquid charge for subsequent use, or by heating of wash water. Heat can also be recovered in deinking plants. Consideration was also given to the recovery of heat from machine rooms. Mr. Dean concluded his paper by describing the operation of steam accumulators.

The next paper, "'Selection of Steam Pressures and Temperatures for Paper Mill Power Plants," was prepared by M. H. Dixon of the St. Regis Paper Co., and W. C. Bloomquist and W. B. Wilson of the General Electric Co. Information was given that should assist the paper mill power engineer to select operating units to give optimum economy and operating flexibility. Data were given on steam flow, exhaust and extraction temperatures, and electrical energy produced by steam turbine generators by which the performance efficiency can be estimated for a range of initial and process steam pressures.

The Steam and Power Session was followed by the Mill Maintenance and Material Session. William McIntosh, Jr.,

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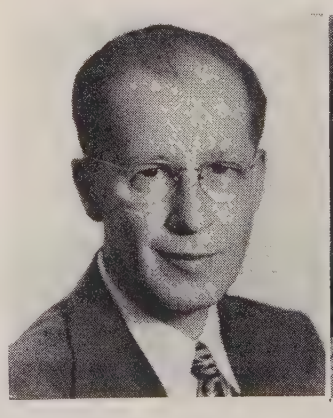
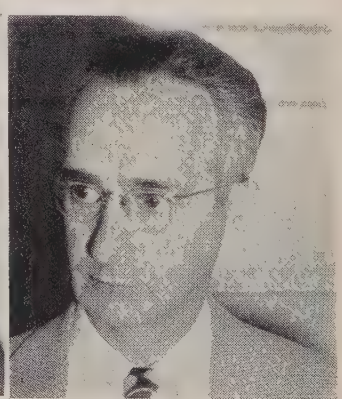
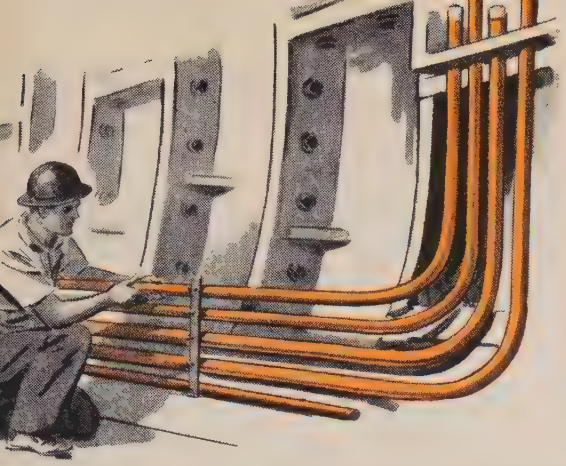


A. E. Montgomery, Chairman, Drying and Ventilating Committee



Albert S. Goodrich, Chairman, Electrical Engineering Committee



NO PLACE FOR REPLACEMENTS HERE!

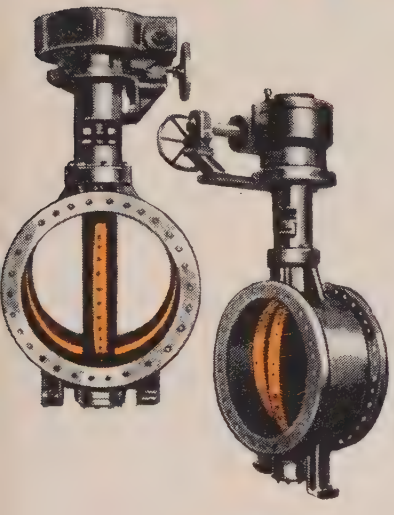
. . . so the nation's biggest underwater tunnel uses Everdur† Electrical Conduit to carry traffic light and control cables. New York's Triborough Bridge and Tunnel Authority, builders of the Brooklyn-Battery Tunnel, made selection on the basis of long-time service records on comparable installations.

WELL, WELL, WELL, WELL

That's right, four of 'em. 38" diameter slotted well screens of Everdur, built by the Layne-Northern Company of Mishawaka for Elkhart, Indiana's water supply. Reasons: strength, weldability, machinability, corrosion resistance . . . and nary a trace of rust!

Watching EVERDUR* At Work

†REG. U. S. PAT. OFF.



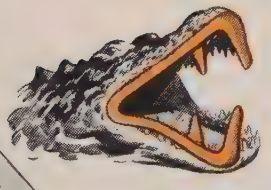
TRAFFIC CONTROLS

Down from the Alvarado Regulating Reservoir rushes the water supply for San Diego at 100-lb. pressure. Many of the vital parts of these mechanical traffic cops are made of Everdur for long operating life. These big butterfly valves, up to 42" I. D., were made by Coldwell-Wilcox Division of Krajewski-Pesant, New York.

HAPPY THOUGHT IN A SQUALL!

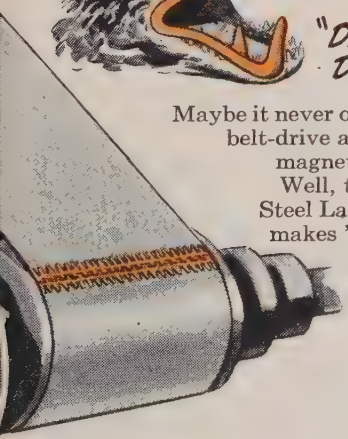
When thunderheads race up and your boat lays over on her beam's end — you pray everything will hang together. That's the time to be thankful for your boat builder's judgment in using strong, tough, non-rust Everdur fastenings

. . . and speaking of seagoing metals, the Design Engineering Company of South Pasadena, California, developed this marine shell block of Everdur. Maximum strength and minimum weight are combined in this one-piece, folded-and-drawn, rivetless block construction. 49190



"DID YOU KNOW" DEPARTMENT

Maybe it never occurred to you that many belt-drive applications require a non-magnetic, spark-resistant lacing. Well, they do. And the Flexible Steel Lacing Company of Chicago makes 'em under the trade name "Alligator." Out of Everdur, of course.



P.S. HOW ABOUT SENDING IN YOUR STORY ON EVERDUR?

WHAT'S YOUR METAL PROBLEM?

Maybe Everdur can help. Our Technical Department is always ready to serve. Just write to The American Brass Company, Waterbury 88, Connecticut. In Canada: Anaconda American Brass Ltd., New Toronto, Ontario.

Where corrosion resistance counts

ANACONDA

COPPER-SILICON ALLOYS*

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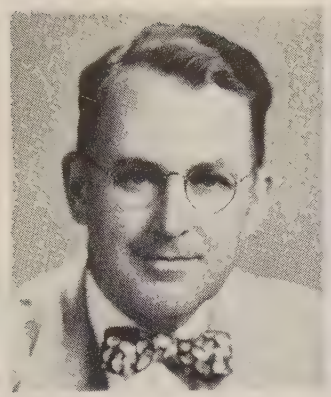
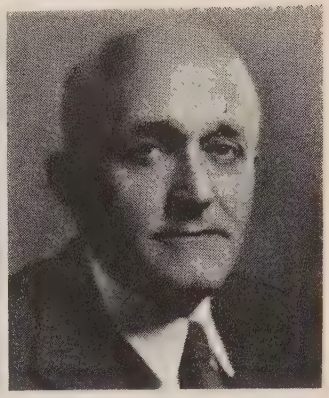


Henry J. Perry, Chairman, Data Sheets Committee



J. W. Hemphill, General Secretary, TAPPI Engineering Division

of the southern Corp., Charleston, S. C., assumed the chairmanship of the meeting. The paper, "Maintenance Cost in Fine Paper Mills" was by D. Ross-Ross, of the Howard Smith Paper Mills, Cornwall, Ont., who outlined the efforts of the fine paper industry in Canada to obtain industry-wide data on the cost of maintenance. Maintenance constitutes about 5% of the sales value of products in the pulp and paper industry, and it is generally recognized that this cost is one of the most difficult to control. Many ways have been devised in an effort to reduce maintenance expenses to a minimum, such as adequate cost control systems using tabulation cards, budgetary systems with or without a monetary incentive for the maintenance staff, and actual wage incentives for all shop employees.

The fine paper industry in Canada is sharing information in which maintenance cost per ton or per hour in the case of paper machines are compared. Further studies are being conducted with a view to relating such cost to insurable values of plant and equipment and to sales dollars. A questionnaire was sent to eleven mills and figures were obtained for one year. These were not too satisfactory because of the effect on the data of unusual maintenance items, so the study has been expanded to cover a five-year period to give a better average. The problem of comparison is not a simple one because of the differences in the accounting methods employed between different companies.

Mr. Ross-Ross indicated that Canadian companies are particularly desirous that American mills will wish to participate in the exchange of information and thus make the data more valuable because of the greater extent of the study.

Carl W. Ziegenbusch of the Mead Corp., Chillicothe, Ohio, then presented a discussion of the application of asbestos cement pipe at the Mead Corp., in his paper "Asbestos Cement Pipe for Overhead Piping Systems."

The application of asbestos cement pipe for overhead piping systems has presented some interesting problems. Many different couplings have been used for putting together asbestos cement pipe in overhead piping systems, and the screwed cast iron flange and the Simplex sleeve coupling which are those most generally used at Mead was described.

Preparation of asbestos cement pipe for service as flanged pipe includes the following steps: (1) finishing to a specific outside diameter at the ends of each section of pipe. This is done on a lathe and is for the purpose of removing the outer layers of the piper which often are a bit softer than the remainder of the pipe. (2) Threading the pipe. (3) Screwing on the cast iron flanges and lining up bolt holes. (4) Finishing ends of pipe and flanges flush after flanges are in place. Sometimes short "filler pieces" which are unflanged are used. Long bolts between flanges on pipe lengths adjacent to these sections pull up the joints sufficiently to insure a tight line. Rubber ring gaskets seal these joints. Simplex sleeve couplings are used as chest inserts and to place short sections of asbestos cement pipe between fixed flanges. The latter usage insures easy installation and removal.

Experiences with flanged asbestos cement pipe have indicated the extreme importance of the following: (1) flanges must be fitted very tightly to the pipe, (2) the ends of the pipe and flange hubs must be flush, and (3) the pipe must be very carefully erected to eliminate strain and must be adequately braced.

The last paper of the morning was presented by P. J. Wilson of the Wilson Carbon Co., New York, N. Y., who described with supporting data the results of laboratory tests on a new carbon base compound that has some unusual properties for case hardening plain carbon steels.

The afternoon of Tuesday, November 1, was devoted to round-table sessions. The Steam and Power group led by J. C. Spahr, Westinghouse Electric Corp., J. L. Kerr, General Electric Co. and H. R. Arnold of the Union Bag and Paper Corp., discussed the standardization of steam turbines. C. H. Groom of Dowell Inc., and M. F. Schnaufer of the Detroit Sulphite Pulp & Paper Co., discussed the cleaning of boilers. F. E. Hutton of Babcock & Wilcox headed the discussion on the instrumentation of steam and power plants.

R. A. Packard led a discussion of paper machine drives at the Mill Design and Economic Aspects group meeting.

The subject for the Engineering Research and Machine Design Comittee was stock flow and pipe friction. K. J. Mackenzie of the Eastman Kodak Co., introduced the subject by reviewing a recent translation of "A Study of the Pipe Friction Losses of Paper Stock Suspensions" by W. Brecht and H. Heller of the Technical High School in Darmstadt, Germany. This paper was originally published in 1935, and still constitutes a basic treatise on the subject.

The Materials Handling round-table was presided over by George E. Hageman, Associate Editor of the Ronald Press, and Mr. Foster's paper as well as other miscellaneous inquiries were discussed.

S. A. Staege of the Black-Clawson Co., introduced the Paper Manufacture (Fourdrinier) meeting by describing the hydronamic inlets. The discussion was continued under the chairmanship of Albert E. Bachman of the Missisquoi Corp., Sheldon Springs, Vt.

(continued on page 44 A)

Longview Fibre Co. wood yard. Storage capacity 16000 cords. All input and outgo from wood yard handled by one man

FOR EXCEPTIONAL COVERING POWER, BRILLIANCE AND STRENGTH... YOU NEED DU PONT MOLYBDATE ORANGE YE-428-D

Versatile Du Pont Pigment for beater and coated paper uses . . . is economical . . . blends well . . . adds distinction!

HERE'S AN OUTSTANDING PIGMENT for your next coloring job—whether fancy printed paper, coated paper or twisting paper. It's a versatile color which blends well with either yellow or red—to give truly distinctive tones.

Molybdate Orange YE-428-D is standardized for both beater and coated paper uses. It can be used in flinting and frictioning—wets readily with water—mixes well with casein and other sizes—won't bleed in water. And it's best for economy—compared to either organic orange pigments or regular chrome orange pigments.

Ask your Du Pont salesman for details, or write . . . E. I. du Pont de Nemours & Co. (Inc.), Pigments Department, 1007 Market Street, Wilmington 98, Delaware.

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DU PONT PIGMENTS
FOR QUALITY PRODUCTION

DU PONT

BETTER THINGS FOR BETTER LIVING
. . . THROUGH CHEMISTRY

(continued from page 42 A)

Tuesday's program was concluded by a dinner given by a group of machinery and equipment manufacturers who sponsored this affair: Bird Machine Co.; John W. Bolton & Sons, Inc.; Cheney Bigelow Wire Works; Clark-Aiken Co.; Draper Bros. Co.; The Foxboro Co.; General Electric Co.; Holyoke Machine Co.; Improved Paper Machinery Corp.; E. D. Jones & Sons Co.; Lodding Engineering Corp.; Lumsden & Van Stone Division, Midwest Piping & Supply Co.; Charles T. Main, Inc.; Magnus Metals Division, National Lead Co.; Mason-Neilan Regulator Co.; Mt. Hope Machine Co.; Norton Co.; Poirier Control Co.; Portland Copper & Tank Works Co.; Rice Barton Corp.; Riley Stoker Corp.; Simonds Saw & Steel Co.; The Sinclair Co.; Stone & Webster; Stowe & Woodward, Inc.; The Torrington Co.; Morton C. Tuttle Co.; Tyre Rubber Co.; Union Machine Co.; Warren Steam Pump Co., Inc.; Westinghouse Electric Corp.

Milton Jacobs of the Charles T. Main, Inc., acted as toastmaster.

Meetings on Wednesday, November 2

The program on Wednesday, November 2, was devoted to drying and ventilating. A. E. Montgomery, J. L. Ross Engineering Co.; Chicago, Ill., chairman of the committee, introduced A. C. Smith of the Newton Falls Paper Co., Newton Falls, N. Y. who presented his paper, "Water Heating System and Briner Economizer." This was followed by the paper, "Heating and Ventilating the Minnesota and Ontario Paper Co. Bleachery" which was prepared by their chief engineer, J. H. Davidson. Mr. Davidson described the new bleach plant at their International Falls Mill. The plant consists of a 100-ton six stage kraft bleachery, a 100-ton two stage hardwood sulphite bleachery, and there is provision for a single stage 75-ton groundwood bleachery.

The bleach plant buildings are of structural steel and reinforced concrete construction with brick and tile walls and have a combined volume of 890,000 cubic feet. Air filters, steam heaters, gas absorbers, and air tempering recirculation systems are provided. The bleach liquor making building is separate from the main building and has its own heating and ventilation system.

In the design of the main building, the washer or operating room is pressurized and isolated from the remainder of the building to protect the personnel and equipment against exposure to toxic and corrosives gases, chiefly chlorine.

A. S. Goodrich of the Hammermill Paper Co., Erie, Pa., Chairman of the Electrical Engineering Committee opened that committee's meeting with "Power Requirements for Paper Machines" which was a summary of data on the power requirements of modern paper machines. With the development and application of sectional electric drives for paper machines, power required for each section can readily be measured. Some of this information has been published in Technical Association Papers previously. From these data constants of power required per inch of width and per 100 feet of speed per minute were recommended for use to estimate the power required. These constants cannot be considered rigid because corresponding sections of similar machines on similar weights and trades of paper show a variation of 2 to 1. Similar or larger variations have been noted on an individual section of a machine on the same grade and weight of paper.

The trend in paper machine design is for larger and faster machines, making a wider variety of products. Sections for special treatment of the paper have also been added. Nip pressures of press sections are being increased.

Data have been obtained from modern machines installed during the past ten years and used to check or revise the contents. Recommended power constants for the various sections of paper machines were included in the report and some of the unusual or special cases that affect power requirements were described. The data are valuable not only for the purpose of selection of drives but as a guide to the machinery builder for checking or improving his design. It is valuable to the paper manufacturer as a guide to the mechanical performance or condition of the equipment and gives a means of finding some of the variables or difficulties of machine operation.

The final formal paper, "Electrification of a Pulp and Paper Mill" was presented by J. C. Lynch, also of the Hammermill Paper Co. Mr. Lynch described the electrification of a pulp and paper mill which started operations in 1899. With the exception of a few initial years of operation, electric power has been utilized for auxiliary drives from the earliest days of the company's pulp and papermaking activities, and as far back as 1920 the program of electrification of main drives was started.

Today the company operates a 21,000-kw. central power station to serve a pulp and paper mill with an average daily output of 300 tons, completely electrified and driven by approximately 1500 motors, totalling 28,000 hp. The paper traced the history of this generating station and the growth of the papermaking facilities and paper production which made it necessary.

The TAPPI Engineering Division Luncheon was held Wednesday noon with A. E. Bachmann, Chairman, the speaker was Dr. George R. Harrison, Dean of Science, Massachusetts Institute of Technology. In his discussion, "The Control of Energy," Dr. Harrison emphasized that the prosperity of the nation, and indeed of the world, depends on expansion of industry, and this in turn depends ultimately on the ability of the scientist and of the engineer to harness energy to the uses of mankind. Figures were quoted from several industries to show how research has made possible a better product at a cheaper price, through increasing sales and boosting both profit and wages. According to Department of Commerce figures, in 1926, 200,000 mechanical refrigerators were sold at an average of $400 apiece. As a result of research and the increased know-how which resulted, a much better refrigerator could be sold ten years later for $160 or less than half as much, so 2,000,000, or ten times as many, refrigerators were sold. In 1909 the average worker could for one hour's work purchase enough automobile tires to carry his car for 20 miles. In 1949, for one hour's work he can purchase tires enough to carry him 2000 miles—another example of improved standard of living resulting from better control of matter and energy. Such technical progress can be summed up by pointing out that at the time of the American Revolution, 18 men out of every 19 had to be farmers in order to feed the 19 families, whereas today 18 farmers can feed 85 families, thus leaving 67 men to go into other occupations necessary to carry out a more advanced social structure.

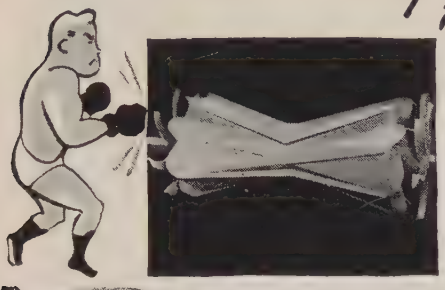
While science has greatly improved our knowledge of how to control energy in the past 50 years, we still have much to learn. The development of power from atomic nucleus is only a small part of the problem. Each day more than 200,000 times as much power as is used for all purposes of industry and transportation falls on the earth from the sun, and to the degree that we learn how to harness this energy will the wealth of the average citizen be increased.

The automobile was cited as an example of a device resulting from very good engineering and very poor science. We use gasoline automobiles because twenty times as much energy can be stored in a pound of gasoline as in 1 pound of storage battery. If a light storage battery could be devised, the automobile could be greatly simplified and the unit cost of transportation greatly diminished.

(continued on page 46 A)

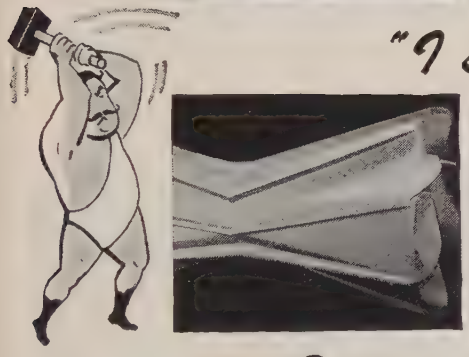
4-way PULPING

"I pound"



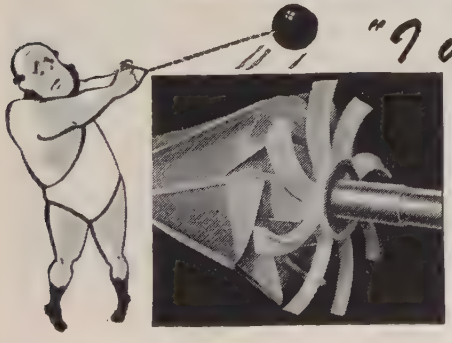
Diagonal bars on Pulp-Master Rotor quickly break up fresh charges of stock.

"I slam"



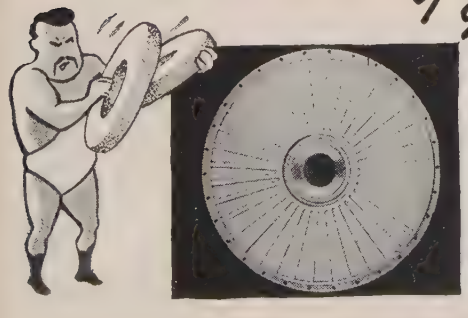
Cone shape of Pulp-Master Rotor forces stock violently against sides of tank.

"I whirl"



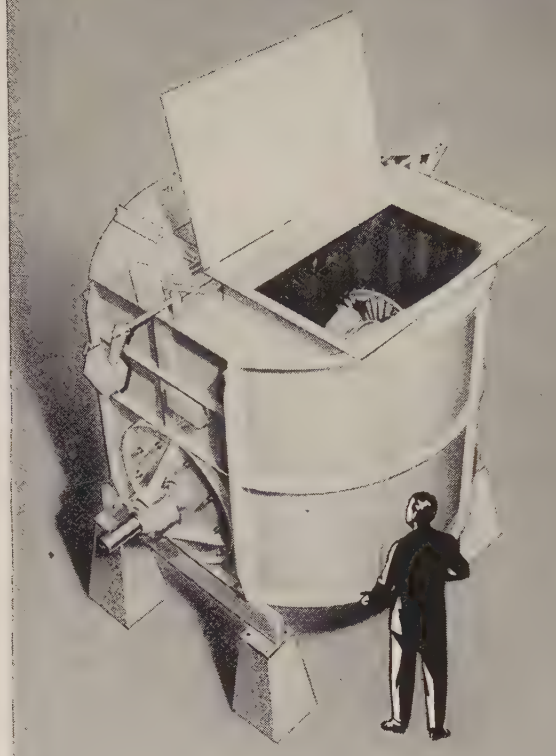
Impellers agitate stock until sufficiently reduced to rub against refining discs.

"I grind"



Refining discs at sides of tank have radial bars against which stock is rubbed by impellers.

POWER!



Not just a swish or swirl, but a pounding, slamming, whirling, rubbing action that completely disintegrates new pulp, waste-paper, machine broke — even glassine and wet-strength — in 10 to 40 minutes. The 4-way action quickly breaks down material into pieces that can be thoroughly reduced by the rubbing of impellers against refining discs.

Four sizes, from 500 to 4000 lbs. at 6½% density. Available for batch or continuous operation. Write for Bulletin EDJ-1019-A — or arrange to see the Pulp-Master in action on your own stock.

P-1

E.D. Jones

PULP-MASTER

E. D. JONES & SONS COMPANY, PITTSFIELD, MASS.

BUILDERS OF QUALITY STOCK PREPARATION MACHINERY

(continued from page 44 A)

Most technological progress results from contributions from the three fields: science, applied science, and engineering. As these fields merge, it is not always easy to distinguish one from the other, but in general the scientist explores some field of nature for anything he may find in it, knowing everything he finds will eventually be useful; the applied scientist attacks a specific problem using all available information to develop a phonograph or a radar or an atomic bomb, while the engineer repeats over and over again solutions of problems which are somewhat similar to one another, always keeping the economic aspect foremost in mind, and endeavoring to make each solution more acceptable than the last. Any branch of engineering grows most effectively when the channels between it and the sciences which feed it are kept open.

The importance of keeping balanced the various fields of science, applied science, and engineering, so that the greatest progress might result was emphasized. At the present time scientists have an increasing tendency to throw all of their energy into exploration of the atomic nucleus. This is very important, but it is equally important to keep advancing on an approximately uniform front all branches of science; otherwise, we shall find ourselves increasingly in the situation of the automobile manufacturer, who does not know how to control energy well enough to put it into a light storage battery, and hence must use gasoline engines which are not even able to start themselves.

The speaker emphasized the role of energy in raising the subsistence level of retarded areas. He belives that too much emphasis is placed on conflicting ideologies as responsible for our present world difficulties, and too little responsibility is assigned to the situation of people who just do not have enough to eat. The scientists and engineers of America have an opportunity to make a contribution to world freedom such as never existed before.

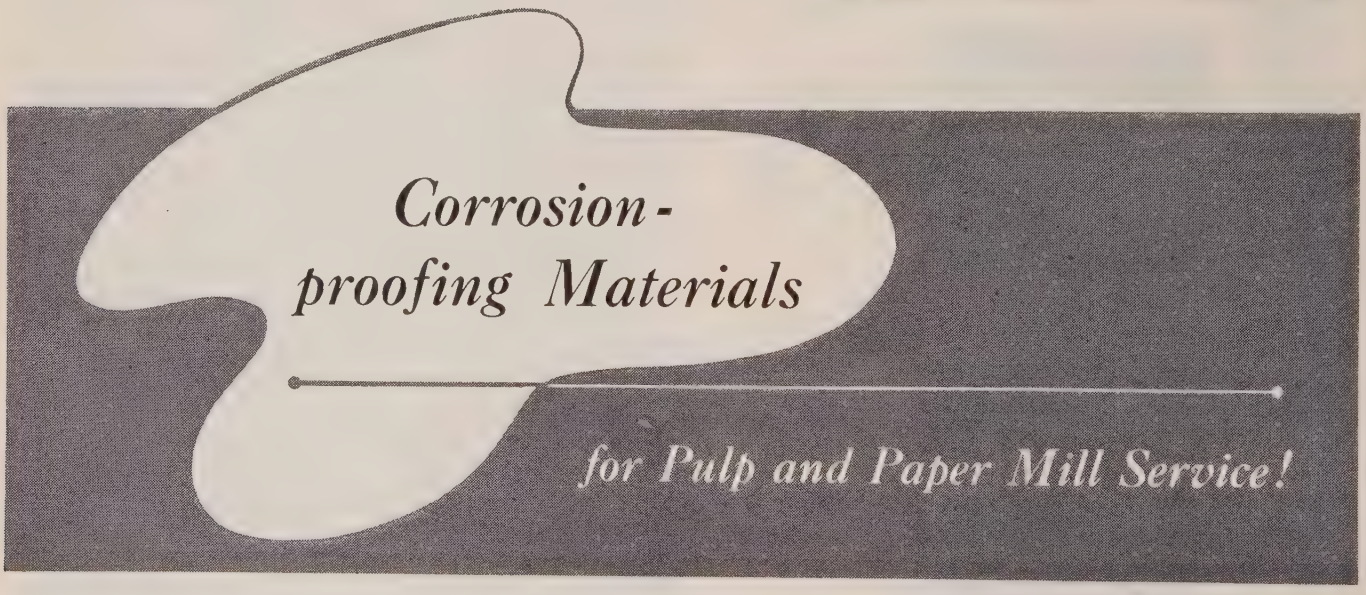
The remainder of the day was devoted to further round-table discussions by the Mill Maintenance and Materials, Electrical Engineering, Drying and Ventilating, and the Paper Manufacture (Cylinder) committees. A. E. Bachmann led a discussion on cylinder machine operation in the last named group meeting.

Thursday, November 3

Thursday was devoted to plant visits, and arrangements were made for trips to Walpole, Worcester, and Lynn, to see the plants of Bird & Son, Inc., Bird Machine Co., The Foxboro Co., Draper Bros. Co., Rice Barton Corp., Norton Co., Riley Stoker Corp., Lodding Engineering Corp., and General Electric Co.

Some of the individuals preferred to go to one of the local paper companies who very courteously extended an invitation to the individuals attending the conference to visit their plants if they so desired.

Preparatory to the Fourth Engineering Conference, a committee consisting of: M. Jacobs, Chas. T. Main, Inc., Chairman; H. G. Ingraham, Bird Machine Co., Treasurer; E. T. Jones, Chas. T. Main, Inc., Secretary; C. E. Barton, Rice Barton Corp.; R. E. Briggs, Draper Bros. Co.; A. L. Lincoln, Jr., Tileston & Hollingsworth Co.; Robert Nivison, Improved Paper Machinery Corp.; D. H. Putnam, General Electric Co.; and Roy Tewksbury, Stowe-Woodward, Inc., was formed to arrange for the many details which accompany such an undertaking. To these individuals, their companies, the sponsoring group of equipment and machinery manufacturers, and to the managements of the local paper companies appreciation was expressed for their cooperation.



Atlas can solve your corrosion problems.

ATLAS ALKOR, the original alkali and acid proof cement can be used in digester ceramic linings and as a general purpose cement in the pulp and paper industry.

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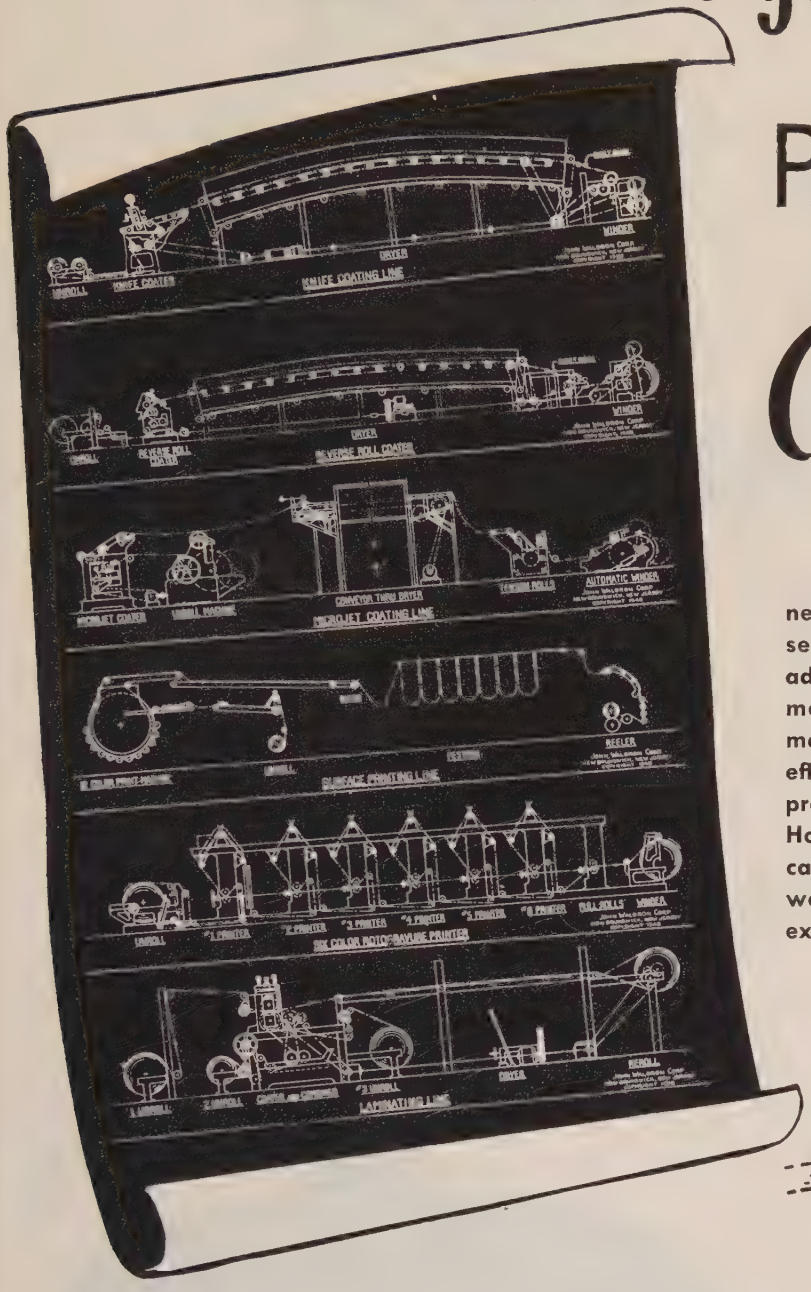

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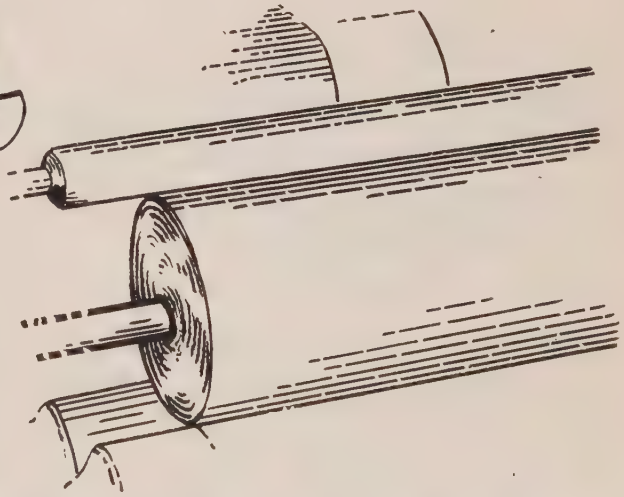

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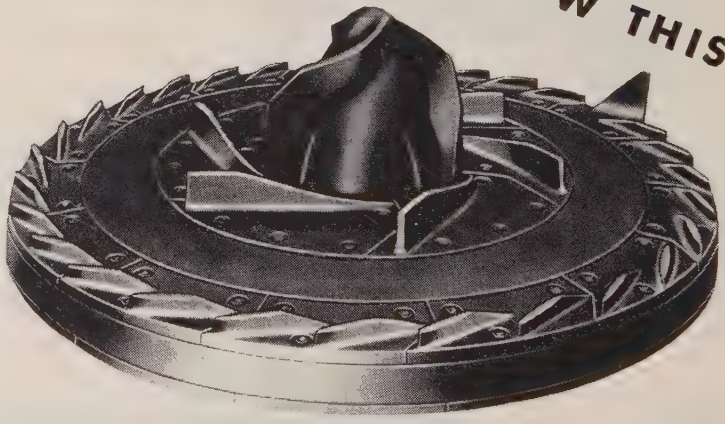

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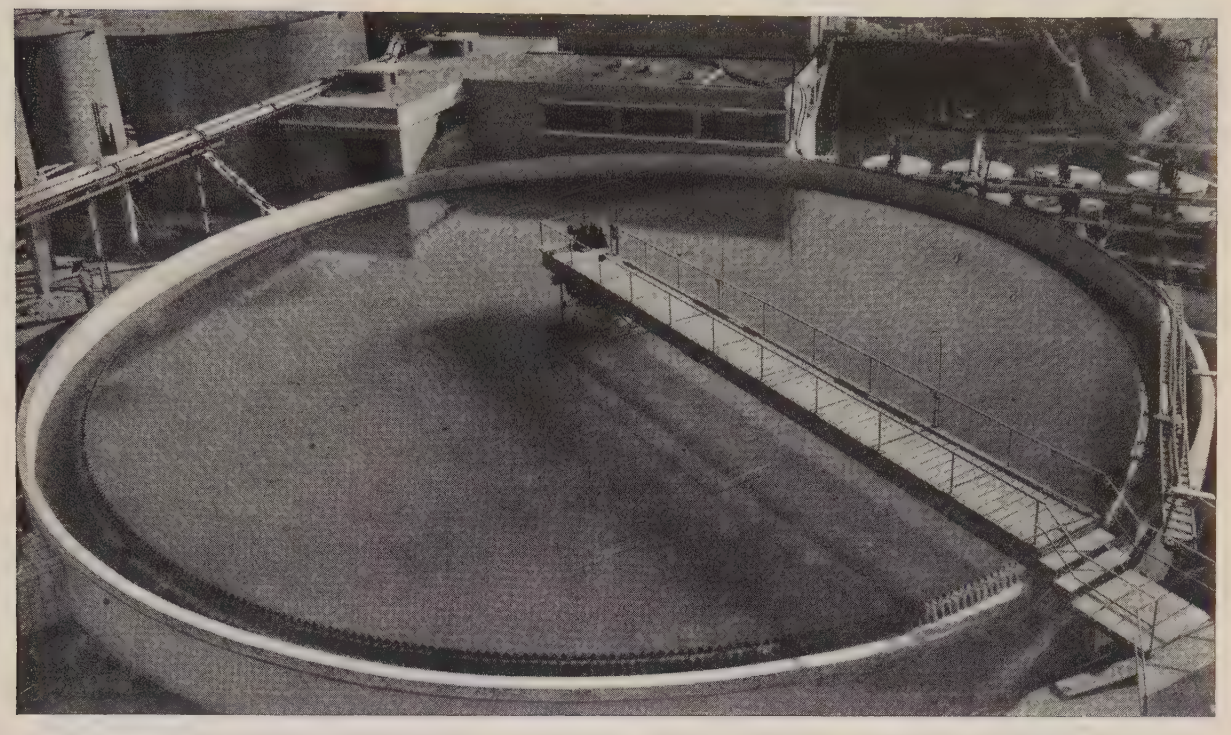

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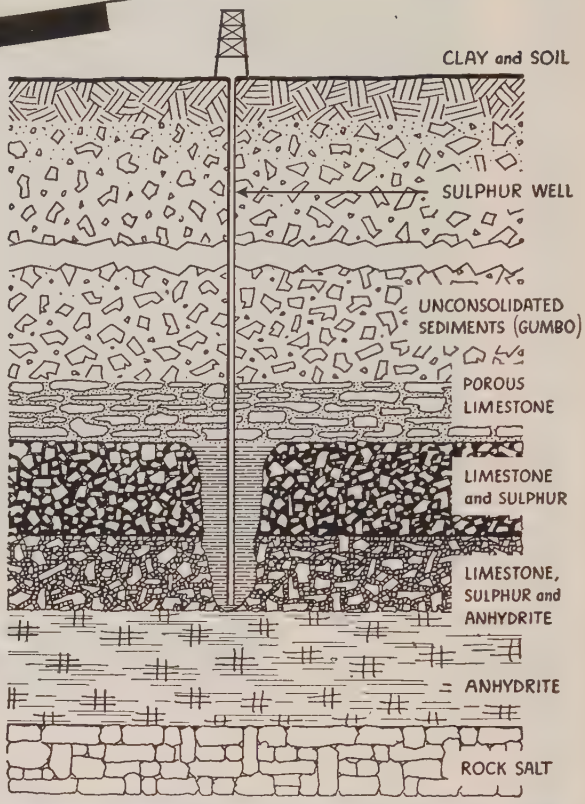

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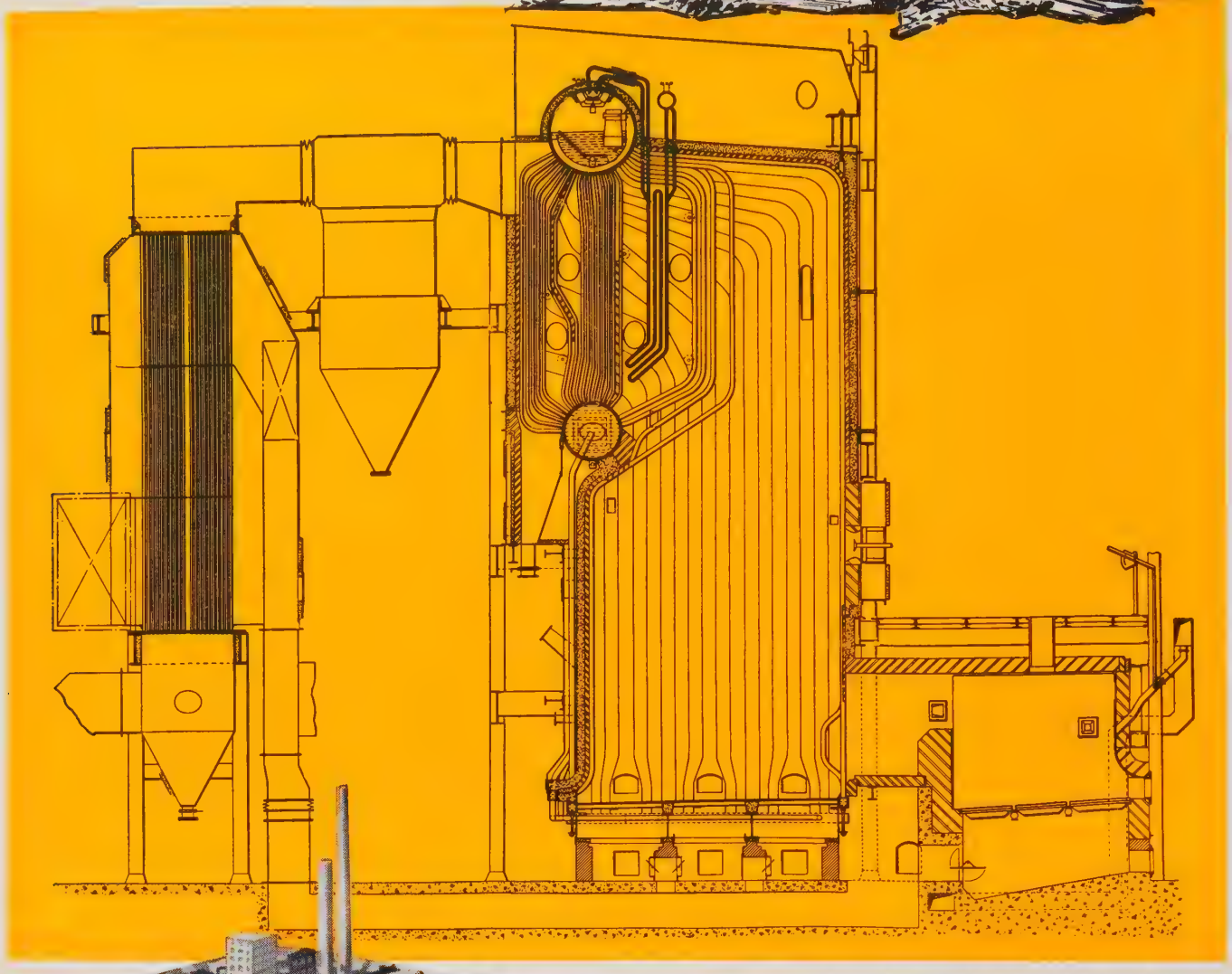

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P-44

Technique of the Biochemical Oxygen Demand Determination

D. PAUL ROGERS

Irregularities in reporting biochemical oxygen demand (B.O.D.) results among analytical and research chemists have been recognized and an endeavor has been made to correct them. The method of making concentrations has been modified and the determination of the immediate oxygen demand (I.O.D.) has been eliminated entirely from the B.O.D. test. There has been added a new arbitrary factor by which the results are determined from the values of the various concentrations by a simple calculation to a 50% oxygen depletion not only for normal wastes but also for wastes containing toxic materials. An optimum B.O.D. range for reliable oxygen depletions has been developed for toxic wastes.

THE CLEAN stream programs have created a very active interest in the determination of the biochemical oxygen demand (B.O.D.) of substances in both sewage discharges and industrial wastes because it is an important measure of pollution.

Some industrial laboratories report the highest B.O.D. results, others the lowest, and some commercial and some research laboratories submit all or the average of the values obtained from the various concentrations used in the determination. There is therefore a need for some acceptable procedure which will prevent such irregularity in obtaining and in reporting results.

The purpose of this paper is an endeavor (1) to simplify certain phases of existing methods with the intention of making a further development in the B.O.D. test, and (2) to present a specific procedure for a uniform method of selecting the final result of the sample from the various concentrations used, in order to secure reproducible and comparable results.

DEFINITION OF B.O.D.

The B.O.D. of any sewage, industrial waste, or other high B.O.D. substance is understood here to be the amount of dissolved oxygen required by the mixed population of organisms in a sample during incubation for 5 days at a temperature of 20°C., and at a 50% oxygen depletion. Dissolved oxygen from the atmosphere is needed by these organisms in the process of changing the organic matter from an unstable, complex form to one that is simpler and more stable. Soluble organic matter is digested before the insoluble compounds are attacked. B.O.D. most frequently consists of the decomposition of carbohydrates.

The determination usually covers a 5-day period in which 68% of the biochemical oxygen demand is satisfied for sewages and for some industrial wastes. B.O.D. results are aids in designing treatment plants and valuable in estimating the amount of fresh water necessary to dispose of organic pollution by means of dilution.

The test consists of making dissolved oxygen determinations on various concentrations of the sample before and after the incubation period. The differences between the initial and final dissolved oxygen multiplied by their concentration factors give values of the various concentrations. Certain rules or regulations are employed in the subsequent procedure to transform these results to the B.O.D. of the sample.

Limitations of the Test

In the definition of the biochemical oxygen demand certain arbitrary factors in the test itself are implied. First, the presence of a mixed population of organisms consisting of bacteria and plankton is required at all times. Fresh normal sewage meets this requirement. Second, diluting water containing fixed amounts of minerals, nitrogen, and phosphorus is also required. Third, the incubation period is set at 5 days because it appears to have the most definite relation to the values of other periods of incubation. Fourth, the temperature of incubation is chosen at 20°C., because it gives a better range for oxygen depletion, less difficulty with supersaturation of dissolved oxygen, and more consistent results, than at either 37°C. or at 10°C. Fifth, the final B.O.D. value of the sample is calculated to a 50% oxygen depletion because, under ideal conditions the principles of biological procedure are maintained in that: the population growth of the bacteria is about at its maximum, there is no overcrowding, the food supply is still sufficient, the dissolved oxygen content is ample, and the increasing rate of growth has not yet changed to a decreasing one.

The earliest recommended oxygen depletion range of B.O.D. was 30 to 60%. In 1917, the recommended range was 20 to 90% which was said to give "perfectly reliable results." In 1930, it was 25 to 75%, giving "reliable results," and in 1946 to the present time, 40 to 70% is said to give "most reliable results."

Averaged results within these allowable ranges came very close to the 50% oxygen depletion.

Interferences and Their Elimination

The test must proceed without any interruption due to the presence of strong acids, caustic alkalies, salts that affect the dissolved oxygen determination, salts that inhibit or hamper the liberty of the organisms, and bactericidal substances in excessive amounts. If these interferences are present, their effects must be eliminated.

D. PAUL ROGERS, Principal Chemist, Pennsylvania State Department of Health, Harrisburg, Pa.

In order to prevent retardation or the inhibition of biological activity, certain requirements are necessary. There must be freedom by which the bacteria may thrive without interruption. It is known that bacteria live happily, normally, under a pH environment of about 4.0 to 8.0. The first step is to make sure that the sample is within this range. If not, neutralize it with a standard solution, either of sodium hydroxide or of sulphuric acid to a pH of about 7.0.

Second, if the sample contains substances which either affect the content or interfere with the determination of dissolved oxygen, a preliminary treatment is necessary, for example, the hypochlorite treatment for sulphites.

Third, if the sample contains substances which precipitate within the above pH rang and, because of flocculation and adsorption gather the bacteria and remove them from the solution by settling to the bottom, thus hampering their liberty to move throughout the entire sample during incubation, the incubated samples must be kept either in constant agitation or must be diluted sufficiently to prevent such interference. Iron, aluminum, and chromium salts are samples of this interference.

Fourth, if bactericidal substances, such as phenols, cyanides, or copper salts, are present, they may be rendered inactive by dilution provided the organic matter is sufficient to be evaluated. These materials must not be in the incubated samples in excess of 4.0 p.p.m. for phenols, of about 2.0 p.p.m. for cyanides, and 0.1 p.p.m. for copper.

THE B.O.D. TECHNIQUE

Sampling

In order to secure a sample that is truly representative of the material on which an analysis is desired, sampling must be carried out with care and accuracy. If a grab sample is desired, the collection should be a portion of the well-mixed material. If a composite sample is desired, half-hourly or hourly grab samples over a period of 8 or 12 hours should be combined in a large container in volumes that are proportional to the rate of flow occurring at the times of collection. A portion of this mixed composite is used for analysis.

Apparatus

A 20°C. incubator, small B.O.D. bottles of 135 ml. capacity with glass stoppers attached by special ties and numbered consecutively 1, 2, 3, 4, etc., bottles in which the various concentrations are mixed, dispensers for transferring the prepared samples into the B.O.D. bottles, other necessary bottles, siphons, automatic burets of the Squibb type, pipets, graduates, and a measuring flask to deliver 100.7 ml., are used in the following technique for B.O.D. precedure.

Reagents and Standard Solutions

The dissolved oxygen reagents of the Winkler method are employed including the use of the azide modification which eliminates the nitrite interference. A diluting water made from stabilized distilled water by the addition of small amounts of minerals and a phosphate buffer solution to supplement wastes deficient in nitrogen has been adopted for general use in our laboratory for about six years. This diluting water is quite similar to the present standard dilution water. Fresh settled sewage is used to give the mixed population in seeding. A soluble starch solution preserved by means of salicylic acid has excellent keeping qualities.

The standard solution of sodium thiosulphate is 0.0125 *N*, 1 ml. of which is equivalent to 0.1 mg. of dissolved oxygen. In titrating 100.7 ml. portion representing 100 ml. original concentration, the number of milliliters of thiosulphate standard used gives a direct measurement of dissolved oxygen in parts per million. The standard thiosulphate solution keeps excellently in an automatic buret which has all openings to the atmosphere fitted with drying tubes filled with soda lime. The strength of the thiosulphate solution must be checked at intervals in order to be certain that it is standard.

The Choice of Concentrations

The ideal concentration is one that under normal conditions will have an oxygen depletion of 50%. The use of two or three concentrations should suffice in most cases to get depletions within the range of 25 to 75% of the initial dissolved oxygen, especially, one above and one below the 50% oxygen depletion.

The following suggestions for concentrations to be made for sewages, treatment plant effluents, and some industrial wastes may be given:

1. Strong sewages	1.0 – 2.0%	concentration
2. Normal sewages	1.0 – 5.0%	concentration
3. Weak sewages	2.0 –10.0%	concentration
4. Effluents from sewage treatment works	5.0 –20%	concentration
5. Pulp and paper mill wastes		
(a) General	1.0 –10.0%	concentration
(b) Mixed	0.1 – 1.0%	concentration
(c) Sulphite waste liquor	0.01– 0.1%	concentration
6. Very strong industrial wastes, such as cannery, tannery, and some milk	0.01– 0.1%	concentration

Inasmuch as two bottles are prepared for each concentration, one for the I.D.O., and one for F.D.O., the volume needed for any concentration is about 300 ml.

Making of Concentrations

1. From the available information of the sample and experience, decide what concentrations are to be made. Suppose, for example, a mixed paper mill waste is brought to our attention. The general range for this type of waste is 0.1 to 1.0%, and three concentrations are selected, 1.0, 0.5, and 0.25%.

2. Since the dissolved oxygen (D.O.) is determined on the diluting water and on each of the concentrations, before and after incubation, there will be needed two B.O.D. bottles for each, making a total of eight bottles (numbered from 1 to 8) for setting up the concentrations. An estimate of the amount of diluting water needed is about 1500 ml. which is prepared in the 5-liter diluting water bottle.

3. By means of a dropper, add 1 drop of settled fresh sewage to each B.O.D. bottle.

4. Fill B.O.D. bottles Nos. 1 and 2 with diluting water by means of a siphon.

5. Dilute 10 ml. of the sample with diluting water to 200 ml. in a graduate or a volumetric flask. Mix thoroughly by shaking. This is a 5% solution.

Concentration Table

Concentration desired, %	*Milliliters used*	*Diluted to milliliters*	*Concentration factor*
50	150 of sample	300	2
25	75 of sample	300	4
20	60 of sample	300	5
10	30 of sample	300	10
5	15 of sample	300	20
2	6 of sample	300	50
1.0	60 of 5% sol.[a]	300	100
0.5	30 of 5% sol.[a]	300	200
0.25	15 of 5% sol.[a]	300	400
0.10	6 of 5% sol.[a]	300	1,000
0.10	60 of 0.5% sol.[b]	300	1,000
0.05	30 of 0.5% sol.[b]	300	2,000
0.025	15 of 0.5% sol.[b]	300	4,000
0.01	6 of 0.5% sol.[b]	300	10,000
0.01	60 of 0.05% sol.[c]	300	10,000
0.005	30 of 0.05% sol.[c]	300	20,000
0.0025	15 of 0.05% sol.[c]	300	40,000
0.0010	6 of 0.05% sol.[c]	300	100,000

[a] 5% solution is made by diluting 10-ml. sample to 200 ml.
[b] 0.5% solution is made by diluting 20 ml. 5% solution to 200 ml.
[c] 0.05% solution is made by diluting 20 ml. 0.5% solution to 200 ml.

6. Dilute 60 ml. of the 5% solution with diluting water to 300 ml. in the dispensing bottle to make a 1.0% concentration. Stopper and mix thoroughly by shaking well. The dispenser stopper carries two glass tubes; one extending from top of stopper to bottom of bottle, the other from bottom of stopper up into the air. Allow air bubbles to escape. Invert the dispenser, insert delivery tube into B.O.D. bottle No. 3, and withdraw the tube gently as the bottle is being filled. Fill bottle No. 4. Empty and rinse the dispensing bottle.

7. Next, make a 0.5% concentration by diluting 30 ml. of the well-mixed 5.0% solution to 300 ml. in the dispensing bottle. Mix and fill bottles Nos. 5 and 6 as in step 6.

8. Now make a 0.25% concentration by diluting 15 ml. of the well-mixed 5.0% solution to 300 ml. in the dispensing bottle. Mix and fill bottles Nos. 7 and 8 as in step 6.

9. Stopper, and place the even-numbered bottles in the 20°C. incubator for 5 days.

10. Let the odd-numbered bottles stand 30 minutes to satisfy the immediate oxygen demand (I.O.D.).

11. Determine the dissolved oxygen (D.O.) on these samples by using 0.5 ml. of each of the reagents and by titrating 100.7 ml. portion which represents 100 ml. of the original concentration. Record the initial dissolved oxygen on the work card in the column marked I.D.O., respectively, for each concentration.

12. At the end of 5 days incubation at 20°C., determine the dissolved oxygen on the even-numbered bottles in like manner and record the final dissolved oxygen in the column marked F.D.O.

13. Substract the F.D.O. from the I.D.O. in each case and record the difference in the column marked Depletion.

14. Substract the blank of the diluting water from the Depletion of each concentration and record the differences in the column marked Depletion less Blank.

15. Calculate the per cent Oxygen Depletion on each concentration by dividing the Depletion by the I.D.O. and multiply by 100.

16. Multiply the Depletion in each concentration by its concentration factor, and record results respectively, in the column marked B.O.D. of Concentration (5-day). These are the unadjusted Values to Be Prorated to 50% Depletion.

Final B.O.D. of Sample Adjusted to 50% Oxygen Depletion

Determine the final B.O.D. of the sample at 50% oxygen depletion from the unadjusted values of the concentrations according to the following: *first,* use only the values of the concentrations whose oxygen depletions are between 25 and 75% of their initial dissolved oxygen; *second,* take two concentrations whose depletions are nearest the 50% depletion, one above and one below. Make calculations by Pearson's Square or by plotting on graph paper at 50% oxygen depletion.

The data on the card of B.O.D. calculations are as follows: 75% depletion has a value of 615 p.p.m.;

B.O.D. Calculations

Concentration of sample, %	*I.D.O.*		*F.D.O.*		*Depletion*	*Depletion less blank*	*% Oxygen depletion*	*Conc. factor*	*B.O.D. of conc. (5-day)*	*B.O.D. of sample (5-day)*
	Bot. No.		*Bot. No.*							
Diluting water	1	9.0	2	8.7	0.3					
1.	3	8.6	4	2.15	6.45	6.15	75	100	615	
0.5	5	8.8	6	5.10	3.7	3.40	42	200	680	
0.25	7	8.9	8	6.85	2.05	1.75	23	400	700	
FINAL RESULTS IN TERMS OF							50			664

42% depletion has a value of 680 p.p.m. These data are used in Fig. 1 on Pearson's Square.

Explanation of Calculation by Pearson's Square

1. In center of square 1, put the desired number of 50%.
2. On the two corners on the left, square 2, place the two numbers corresponding to the oxygen depletions in per cent putting the higher one, 75, at the top.
3. Substract the number in the center from the larger of the numbers on the left and write this number diagonally opposite the larger number on the left in square 3.
4. Substract the smaller of the two numbers on the left from the number in the center and write this number on the remaining corner, as in square 4.

The two numbers on the right side give the parts by weight of the values of the starting numbers repre-

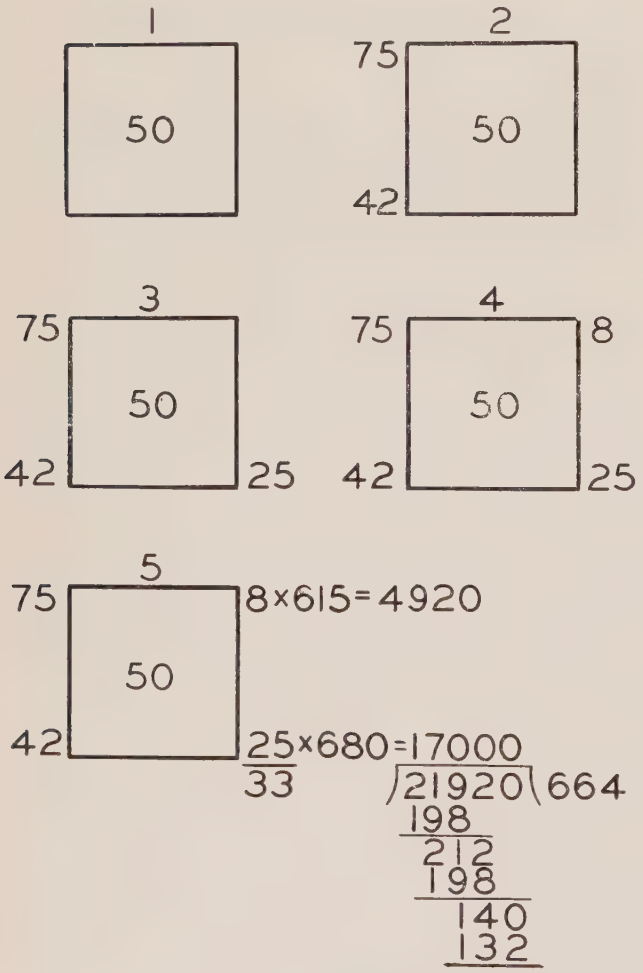

Fig. 1. Pearson's Square is applicable to problem of finding final 5-day B.O.D. value

senting the per cent of each oxygen depletion. In case of the 75% depletion, its value is 615. Eight parts of this value is $8 \times 615 = 4920$. In case of the 42% depletion, its value is 680. Twenty-five parts of this value is $25 \times 680 = 17{,}000$. The sum of 8 parts and 25 parts is 33 parts of a 50% depletion with a total value of 21,920. Since 33 times the value at 50% depletion is 21,920, then the final B.O.D. value in terms of 50% is 21,920 divided by 33, or 664 p.p.m.

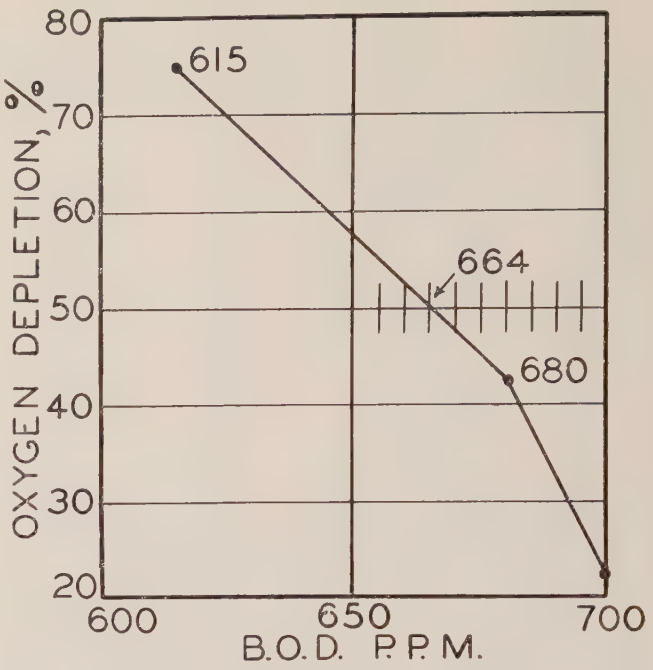

Fig. 2. B.O.D. curve intersecting 50% oxygen depletion line at 664 p.p.m.

5. The above explanation, step by step, in the calculation by Pearson's Square is given because it is not generally known or understood. In square 5, the entire calculation, however, is shown in simplified form.

6. In case a formula is desired to calculate the B.O.D. at a 50% oxygen depletion, Pearson's Square Method may be written in form of an equation.

$$\text{B.O.D.} = \frac{V(50-d) + v(D-50)}{(50-d) + (D-50)}$$

B.O.D. = 5 days at 50% oxygen depletion
V = Value of B.O.D. on concentration at high depletion
v = Value of B.O.D. on concentration at low depletion
D = Depletion above 50%
d = Depletion below 50%

Example:

$$\text{B.O.D. (at 50\%)} = \frac{615(50-42) + 680(75-50)}{(50-42) + (75-50)}$$

$$= \frac{615(8) + 680(25)}{8 + 25}$$

$$= \frac{4920 + 17000}{33}$$

$$= \frac{21920}{33} = 664 \text{ p.p.m.}$$

Calculation by Graph

Plot the B.O.D. values of the concentrations on graph paper against the per cent oxygen depletion and connect the points with straight lines. The point of intersection of this straight line with the 50%

oxygen depletion line determines the final 5-day B.O.D. value of the sample. Figure 2 shows the graph of the example using the same data that were used in the Pearson's Square calculation. The point of the intersection shows the final B.O.D. to be 664 p.p.m. in terms of 50% oxygen depletion.

Figure 3 shows a graphical sketch of the compression of the B.O.D. range giving "reliable" results to a proposed range at 50% oxygen depletion as calculated from the values obtained on various concentrations whose depletions are within the 25 to 75%.

Figure 4 shows uniformity in reporting final B.O.D. along the x axis representing the 50% depletion from values along the y axis representing the 25 to 75% depletions of the concentrations.

Final B.O.D. at 50% Oxygen Depletion For All Wastes

While the technique presented for the determination of the final B.O.D. at 50% oxygen depletion is for normal conditions, it is equally applicable to all wastes and other substances when the interferences of various types either have been removed or rendered ineffective by any satisfactory method. Sulphite waste waters have an affinity for dissolved oxygen at rather a slow rate. The chemical demand is not satisfied within 30 minutes allowed for immediate oxygen demand but persists throughout the 5-day period, and even longer. One can readily see that in a B.O.D. determination not only biological but also chemical oxidatiin is measured in the final result unless this demand is satisfied by the hypochlorite modification *before* making the concentrations for incubation.

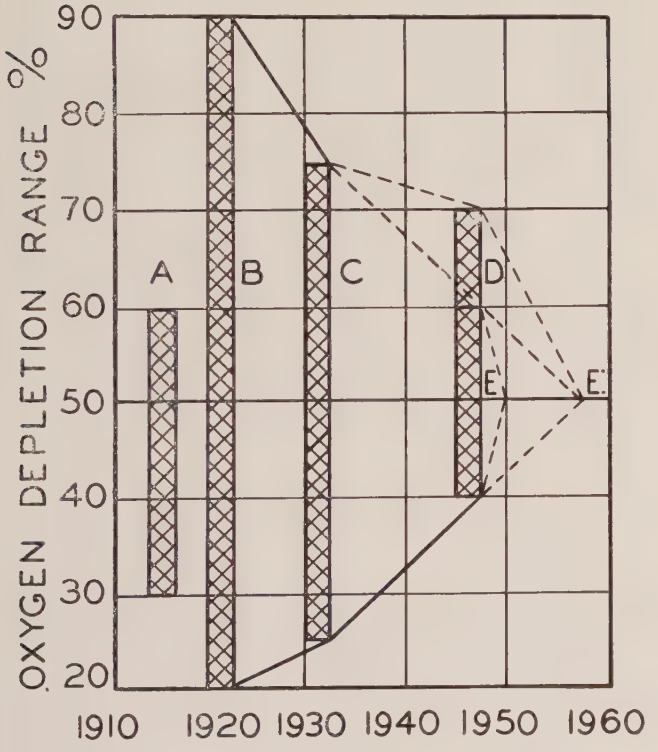

Fig. 3

A—Royal Sewerage Commission 5th Report; *B*—Theriault & Hommon 1918; *D*—Standard Methods U.S.P.H.S.; *E-E.*—Proposed, in terms of 50% (25–75% range).

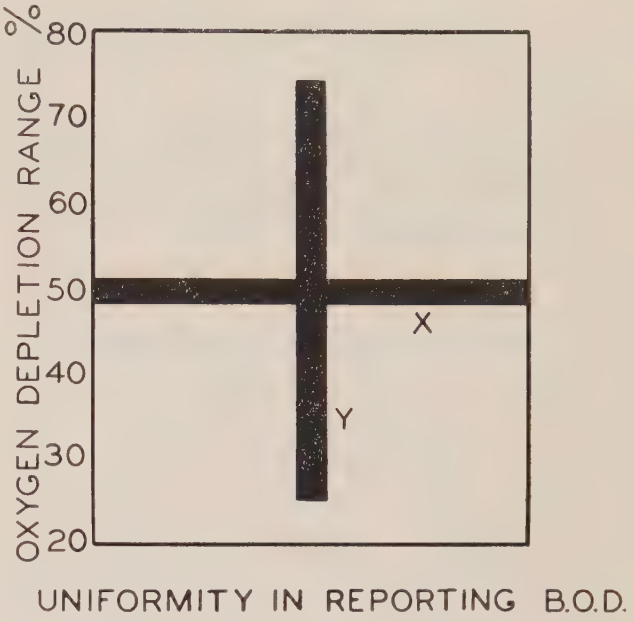

Fig. 4

x = B.O.D. in terms of 50% calculated from concentration values in; y = oxygen depletion range 25–75%.

It is not difficult to recognize the presence of bactericidal substances from the manner in which the oxygen is depleted. In the case of the B.O.D. of phenol, the high concentrations show that only a small amount of dissolved oxygen is depleted during the 5-day period. There is no certainty that the loss of oxygen is due to the organisms and, therefore, it should not be called B.O.D. While the same condition persists even at low concentrations, there is still a lower range in which the oxygen is totally depleted. At very low concentrations there is an optimum range in which occur the depletions of 25 to 75%.

For locating the optimum B.O.D. range on the per cent oxygen depletion curve, in toxic wastes, see Fig. 5.

I.O.D. Is Not B.O.D.

In B.O.D. studies of toxic wastes, it is necessary to keep in mind that the particular substance being measured is the oxygen utilized by the bacteria in digesting the organic matter. Oxygen required by any other means is not a measure of the B.O.D. Certain compounds, such as hydrogen sulphide, ferrous salts, etc., have their affinity for dissolved oxygen satisfied within 30 minutes after the concentrations are made. Oxygen used in such a manner is termed immediate oxygen demand and should be subtracted from the total demand, unless the I.O.D. is allowed to be satisfied automatically before making the initial dissolved oxygen determination as is done in the above procedure.

In order to arrive at some reasonable and satisfactory conclusion concerning the B.O.D. of toxic wastes or materials, it is necessary to make enough concen-

trations for the test so that, at least, one is above and one below the 50% depletion in that section of the depletion curve which has the optimum depletion range.

SUMMARY AND CONCLUSIONS

1. The necessity of making the I.O.D. determination with its calculations has been eliminated in the procedure.

2. A 50% oxygen depletion factor has been added to the other arbitrary factors of the B.O.D. test.

3. Comparable and reproducible results have been obtained when the final B.O.D. results were secured at 50% oxygen depletion.

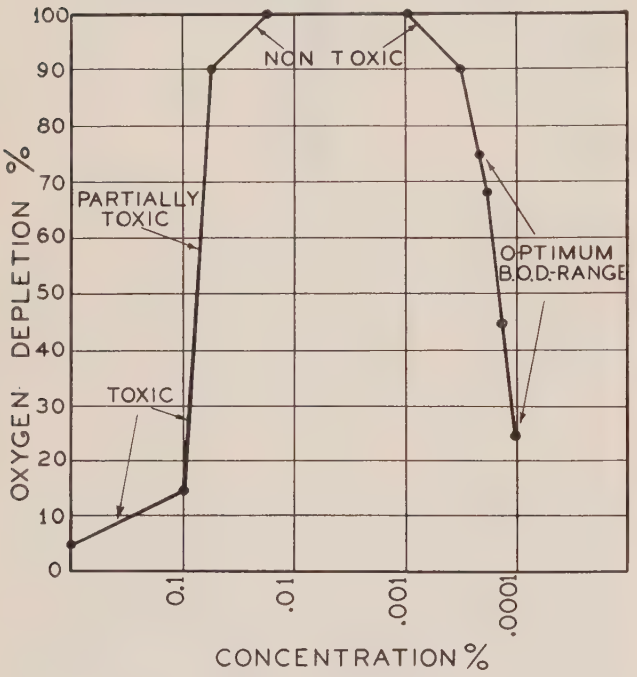

Fig. 5. Curve showing optimum depletion range for B.O.D. in a toxic waste.

It is realized that this paper may be considered by some to be a fantastic or otherwise radical departure from the procedure which many chemists have followed. It is hoped, however, that what has been given will stir up some profound thought and result in an honest, helpful discussion.

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DISCUSSION

Stuart E. Coburn, (Chief Chemist, Metcalf & Eddy, Boston, Mass.): Mr. Rogers has presented a concise and informative paper on suggested improvements in the procedure for determining the biochemical oxygen demand (B.O.D.) of sewage or industrial wastes. By following his procedure, it may be easier to obtain reproducible results.

I wish to discuss this paper briefly from two viewpoints: (1) that of the research chemist trying to improve a method of analysis, and (2) that of the chemist or sanitary engineer attempting to use the B.O.D. determination as a guide in solving a wastes treatment problem.

One of the weaknesses of the B.O.D. determination is the difficulty in getting check results because of the limits of accuracy and precision of the methods used. The Committee on Standard Methods of the Federation of Sewage Works Associations is studying analytical procedures so that the next edition of "Standard Methods of Water and Sewage Analysis" will contain a statement as to the accuracy of each method.

Variations in the nutrients present in the diluting water are likely to produce widely different results for this determination. Mr. Rogers does not use exactly the same type of diluting water recommended by Standard Methods, consequently his results may differ somewhat from those obtained when Standard water is used.

He has described a procedure to use when toxic or interfering substances are present. I wish the solution were as easy as he indicates. Another committee, The Toxicity Committee, of the F.S.W.A., has been working on this question for two years trying to determine the effect of toxic materials on the B.O.D. determination. Much research is being done to improve the analytical methods, and such work as done by Mr. Rogers and others in the field is valuable.

On the other hand, how is the B.O.D. determination used by chemists and engineers? In my opinion, it is only one measuring stick used in determining the effect of sewage or wastes on a stream in a study of a pollution abatement problem. As a tool, it is somewhat analogous to the carpenter's hammer. It is not a precision instrument like the surgeon's scalpel. The determination may be used to provide an approximate comparison of the relative strengths of say, two paper mill wastes, one produced by a plant in Wisconsin, and the other produced in a plant in Pennsylvania.

The results may be used also to compute the theoretical loading of wastes that might be applied to a treatment plant unit, such as "pounds of B.O.D. per cubic yard of filter stone" in a high-rate filter. In these cases, it must be remembered that in the interpretation of results, precise methods of analysis do not in and of themselves provide for accurate conclusions. Representative sampling is essential, and not always easy to obtain. The B.O.D. determination, however, is of real value as a working tool of the sanitary engineer in stream pollution studies, although the results obtained with this tool must be used with judgment.

The lack of precise accuracy in methods may be overshadowed by other inherent weaknesses connected with application of results to specific problems related to stream pollution. I would like to point out some of these weaknesses.

1. The varying rates at which biological processes take place in the dilutions in the laboratory are undoubtedly different from those that exist on some entirely different dilution in the stream. Why is it particularly important to select a dilution ratio which results in just 50% reduction in oxygen?

2. An incubation temperature arbitrarily fixed at 20°C. in the laboratory does not foretell accurately what conditions exist at other temperatures. I found in a study of pineapple wastes treatment in Honolulu, where the temperatures of the wastes were about 26°C., the B.O.D. results obtained by incubation at this temperature were considerably different than if 26°C. B.O.D.'s were computed from determinations made by incubation at 20°C.

3. The seed used in the diluting water in the laboratory makes a considerable difference in the results obtained. One observer obtained results that varied by nearly 20% which were attributed to different samples of sewage used as a seeding material.

4. The quantity and kind of nutrient mineral salts in the stream water, into which the wastes are discharged, produce very different B.O.D. results than when these wastes are diluted with the synthetic waters recommended in Standard Methods.

I have found that when the soft waters in New England streams which receive the specific wastes are used as a diluting medium, the B.O.D. results are much less than when the Standard diluting waters are used. Specifically, on a tannery wastes study, the B.O.D. results with Standard dilution water were 100% greater than when stream water was used. On another problem on wool scouring wastes, the difference was nearly 200%. It is evident, therefore, that totally incorrect conclusions may be drawn when B.O.D. tests on wastes are made to determine their effect on a stream if the tests are made with a "synthetic" dilution water.

In view of the effect of the several variables which always occur in stream pollution problems, I am not too greatly concerned whether the laboratory results for B.O.D. are based on the use of dilutions giving 40, 50, 60, or 70% depletion of oxygen.

C. C. Ruchhoft (Head Chemist, U. S. Public Health Service, Environmental Health Center, Cincinnati, Ohio): Mr. D. Paul Rogers' paper on the "Technique of the Biochemical Oxygen Demand Determination" proposes some variations from the techniques for B.O.D. which have been described in papers from this Center and in the Standard Methods for the Examination of Water and Sewage of the American Public Health Association. Mr. Rogers also proposes a calculation for the B.O.D. that would be obtained with a dilution giving 50% depletion in the sample on the basis of depletions between 25 and 75% in experimental dilutions. This method of calculation is a new approach in the estimation of the B.O.D. of industrial wastes. A principal objection to this paper arises from the fact that the normal variations that occur in B.O.D. determinations, which are bioassays, are not considered critically. There are, as Mr. Rogers has pointed out, a number of factors which influence the rate and extent of the biochemical oxygen demand that is obtained in any experimental case. Comparable B.O.D. results can only be obtained when all these factors have been carefully controlled and the procedure is standardized to provide optimum conditions for the oxidation of the organic matter in the sample by the microflora and -fauna. Even then, it has been shown that variations are to be expected. This was indicated by the variation in the oxidation velocity constant (K) at 20°C., that was found in a careful study reported recently.* Much work remains to be done on seeding procedures to obtain comparable B.O.D. data. We should not agree that the use of 135-ml. bottles to which 1 drop of sewage was added as a seed was a satisfactory seeding procedure for carrying out this test. Drops of settled sewage are far from uniform and the possibility of variations in their size might introduce a considerable variation in the B.O.D. results that would be expected. In our laboratory, a definite quantity of settled sewage, usually 1 ml., is added to a liter quantity of the waste and dilution water mixture in a 1-liter cylinder. This is mixed with the conventional stirring device and siphoned into standard B.O.D. bottles. Years of experience have indicated that greater precision and uniformity can be obtained when dilutions are made up carefully in liter, or larger, quantities and siphoned into standard B.O.D. bottles.

Because of the variability in the reaction that occurs from bottle to bottle, even under the most ideal conditions, there is some variation in the results that are obtained in a replicate series of such B.O.D. determinations. A large amount of experience has indicated that variations in check B.O.D. observations of 5% are common when all factors have been carefully controlled and variations up to 10% are more usual in the routine laboratory. We have found that if two dilutions of the same sample are put up, statistically the one having the higher concentration of organic matter will give the higher B.O.D. in the absence of inhibitors. However, that is the statistical picture and it will not be so in every individual case. There will be some instances where the lower concentration will give the higher 5-day B.O.D. In most cases, the variation between the results obtained in the two dilutions will not be any greater than the 5% variation

* Ruchhoft, Placak, Kachmar, and Calbert. Variations in B.O.D. velocity constants of sewage dilutions. *Ind. Eng. Chem.* 40: 1290 (1948).

mentioned heretofore. This variation between two dilutions becomes greater if nitrification occurs earlier in one dilution than in the other. Uuder such circumstances the B.O.D. obtained in two dilutions may exceed 10%. Our experience indicates that there is a normal variability that must be expected when dilutions are used which give between 25 and 75% depletion in the sample. The normal variation that may be expected in the absence of nitrification is around 5%. No correlation has ever been found between the dissolved oxygen level or the percentage oxygen removed and the B.O.D. as long as there is sufficient oxygen remaining to support the normal aerobic reaction. All tests have indicated that 1 p.p.m. of dissolved oxygen is a satisfactory residual after the 5-day period. Consequently, it does not appear to be necessary or desirable to calculate a B.O.D. value that would be expected in a dilution giving 50% depletion. I do not believe that this practice would contribute to the usefulness of the B.O.D. determination.

Mr. Rogers obtained a B.O.D. of 680 in a dilution giving 42% oxygen depletion. In another dilution, giving 75% oxygen depletion, a B.O.D. of 615 was obtained. The mean value of these two is 647 which compares very favorably with the value of 664 that is obtained by the method proposed. In this case, therefore, the value obtained by the proposed method showed no statistical advantage over the mean obtained in the two dilutions.

It is unfortunate that Mr. Rogers did not present a series of data obtained with the conventional procedure and with the proposed procedure to strengthen his paper. It would certainly be desirable to collect such experimental information on this method of calculation for comparison with the conventional method on a series of sewage and industrial waste samples, if consideration is to be given to this revised method. The acceptance of this method of calculation will depend entirely upon the results obtained when such experiments are conducted.

D. Paul Rogers: The objective of my paper is that of assisting in standardizing the B.O.D. procedure by using a uniform method of calculating the final result when the sample shows variable depletions of oxygen upon incubation.

Results of analyses from hundreds of samples were collected, curves were plotted in various B.O.D. ranges up to 100,000 p.p.m. and studies were made in order to get a general trend of the data. From these observations, an example of a mixed paper mill waste was selected and developed to meet the average conditions.

Small bottles are permitted by Standard Methods. In our laboratory, seeding by adding a drop of fresh, well-mixed, settled sewage to a 135-ml. bottle has been followed for about 25 years. While this procedure gave reliable results on all samples with normal variations, and apparently on those with abnormal variations, it is not claimed to be the only satisfactory method. Furthermore, with 1 drop per 135 ml. from a dropper giving 14 drops per ml., only 0.5 ml. of the seed is used per liter of mixture of waste and diluting water. Therefore the corrective blank value is half of that required with 1.0 ml. per liter.

Abnormal variations in oxygen depletion upon incubation as found in industrial wastes cause a serious problem in the B.O.D. determination. This has resulted in a chaotic disagreement among chemists in concluding and reporting the 5-day B.O.D. Yet, the principal objection to the paper is that *normal* variations present no critical problem. The purpose in making adjustments to a 50% oxygen depletion is to care for abnormal variations, and we think it works equally as well on normal variations.

The present B.O.D. methods permit chemists to use their own ideas in eliminating inconsistent figures as well as in calculating and reporting the 5-day B.O.D. results. A definite procedure should be adopted so that an identical final value of 5-day B.O.D. will be obtained when the same set of figures from various concentrations are considered.

The following illustration shows exactly what I mean. First, just after the session in which the above paper was presented, a professor in the department of sanitation of an Eastern university said to me that there was no problem in the example given in the paper. The value of 680 p.p.m. was a good check with that of 700 p.p.m. and he would take the average of the two and call it 690 p.p.m. Second, a little later another professor from the same university noticed that the average of the three given values was 665 p.p.m. This was the final value he would take. Third, in Mr. Ruchhoft's discussion a mean of the two low values 615 and 680 p.p.m. or 647 p.p.m. was taken for the final 5-day B.O.D. value.

This problem is not as extreme as some that have been found, but nevertheless, three different approaches were used on the identical data and three different answers were found, even though one was practically the same as was given in the paper.

The following table summarizes the three answers and the value found in the paper along with the per cent oxygen depletion of each.

No.	*B.O.D. five-day p.p.m.*	*Oxygen depletion, %*
1	690	33
2	665	47
3	647	59
4[a]	664	50[a]

[a] Final result from calculation as found in paper.

The 50% oxygen depletion value may not be the only right one, but it is certainly not wrong to use because it falls within the 40 to 70% range that gives the "most reliable results." We think there is just as much reason in adding the arbitrary factor "at 50% oxygen depletion" for the purpose of assisting in standardizing the 5-day B.O.D. determination as there was in adding "at sea level" for standardizing barometric pressure.

It is recognized that variables such as arise in the problem of seeding still exist as well as some confusion in general. These must be removed and simplicity in technique and in the final calculation must be developed in order to make the test more conclusive and more useful. Otherwise, if a "great number of variables" continue to confront the analysts, there may be a new dawn when the B.O.D determination is replaced by a chemical oxidation test.

Bioassay of Slime Control Agents in a Pulp and Paper Mill System

I. Lignasan X and Merfenel

B. F. SHEMA, J. B. ANDERSON, and J. W. APPLING

The use of various chemicals for slime control in the pulp and paper industry has increased tremendously in the past eight years. This demand for an effective toxicant has resulted in the introduction of a number of bacteriocides and fungicides for microbiological control. The effective sale of any given slime control agent requires its manufacturers to make specific recommendations relating to its use. These may include recommendations for dosage rates, and these may vary, first, because of the actual toxicity of the active ingredients and, second, because of the amount of the active ingredient present in the compounded product. Because of these variances in dosage rates, it is often desirable to determine quantitatively the amount of a particular toxicant at a given point in a mill system. A method has been developed that is suitable for testing mercurials; by the substitution of the proper organism, it can probably be adapted to the testing of other toxicants.

THE USE of various chemicals for slime control in the pulp and paper industry has increased tremendously in the past eight years. This demand for an effective toxicant has resulted in the introduction of a number of bacteriocides and fungicides for microbiological control in the pulp and paper industry. Some of these materials are very effective and have gained wide use, whereas the use of many others has been restricted to local markets. The more effective slimicides can be conveniently classified on the basis of their active ingredients as follows: (1) chlorine or chloramine, (2) mercurials, (3) chlorinated phenols, (4) quaternary ammonium compounds, and (5) various combinations of these materials.

The introduction or effective sale of any given slime control agent requires its manufacturers to make specific recommendations relating to its use. These may include recommendations for dosage rates, and these may vary, first, because of the actual toxicity of the active ingredient and, second, because of the amount of the active ingredient present in the compounded product. For example, the recommended dosage rates for the mercurials vary from $^1/_{20}$ of an ounce to 16 ounces per ton of fiber (dry basis) and in exceptional cases a higher dosage rate may be recommended. Because of this wide range of recommended dosage rates, it is often desirable to determine quantitatively the amount of a particular toxicant at a given point in a mill system. The chemical procedures used in the quantitative determination of these toxicants are often tedious and time-consuming. Furthermore, the results obtained give only the amount of chemical present and this value is not necessarily an indication of the biologically active material. In order to obtain adequate slime control, it is essential to know the degree of biological activity of a toxicant in a given mill system and it is equally important to determine the length of time that the toxicant is biologically active under normal operating conditions.

In order to detect small amounts of a biologically active toxicant in a pulp or paper mill system, the following method was developed. The method in its present form is suitable for testing mercurials; by the substitution of the proper organism, it can probably be adapted to the testing of other toxicants. It is essentially the same as that used in evaluating the potency of the various antibiotics.

PROCEDURE

Prepare Difco nutrient agar and sterilize at 15 p.s.i. for 20 minutes. Cool to 45 to 50°C. and aseptically pipet about 11 ml. of the medium into a sterile Petri dish (15 by 100 mm.). Care should be taken that the agar is evenly distributed over the bottom of the dish. If the agar begins to solidify before it is evenly distributed, heat the dishes prior to use. After the nutrient agar has solidified (a minimum lapsed time of about two hours or, as an alternative, the plates can be made the previous day), the surface is flooded with about 5 ml. of seeded agar which is pipetted aseptically. It is very important that this seeded agar is evenly distributed over the surface of the nutrient agar. The seeded agar is allowed to solidify for at least 2 hours.

After the seeded agar has solidified in the Petri dish, sterile stainless steel cylinders (6 mm. internal diameter, 8 mm. external diameter) are placed at predetermined positions on the surface of the seeded agar by means of sterile forceps. The stainless steel cylinders are sterilized with dry heat, whereas the forceps are sterilized by dipping in 95% alcohol and flaming.

The seeded agar is prepared by mixing approximately 3 ml. of a heavy nutrient broth suspension of *Sarcina lutea* IPC No. 861 (24-hour culture grown at 37°C.) with 50 ml. of sterile melted nutrient agar (45 to 50°C.). The test organism should be maintained in stock culture on Difco stock culture agar. Monthly transfers are made in order to maintain the sensitivity of the test organism. It has been our experience that when the particular strain of *Sarcina lutea* is transferred daily for a period of two weeks, the organism loses some of its sensitivity. Therefore, if this method

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of bioassay is used daily, it will be necessary to obtain a new subculture of the organism from the stock culture once every two weeks. Before this subculture is used in the preparation of the seeded agar, it should be grown for at least two successive 24-hour incubation periods on nutrient agar prior to its inoculation into nutrient broth. The sensitivity of the new culture is compared with previous cultures by observing the zones of inhibition obtained with a toxicant of known strength.

Each technician must determine the proper time interval between flooding with the seeded agar and the placing of the cylinders in order that a perfect seal is obtained. After placement of the cylinder, an interval of about 15 minutes should elapse before the solution to be tested for its biological activity is put into the cup. If it is suspected that a high concentration of the active ingredient is present, proper dilutions should be made. Since each Petri plate contains three to five cylinders placed equidistant from the center, either three or five analyses can be made on one plate. Generally, five cylinders are placed on each plate. However, when high concentrations of the active ingredient are expected, it is better to use only three cylinders per plate. For every determination, each sample should be replicated at least once. A clean medicine dropper is used to dispense the test solution into the cylinders. It is not necessary that the medicine droppers be sterilized but they should be cleaned with cleaning solution, rinsed thoroughly in distilled water, and dried. A clean medicine dropper should be used for each dilution of the test material. During the time the cups are filled, care should be taken that the surface of the seeded agar does not become unnecessarily contaminated. After the cups are filled with the test solutions, the glass Petri dish covers are replaced with porous clay covers which are used to prevent moisture droplets forming on the covers and dropping down on the test solutions and agar. The Petri plates are then carefully transferred to an incubator. At the end of 24 hours of incubation at 37°C., the diameters of the zones of inhibition surrounding the metal cylinders are measured with the aid of a pair of dividers and a millimeter scale.

EXPERIMENTAL DATA

The described technique was applied in the laboratory to two toxicants which are commonly used in the pulp and paper industry—6.25% ethyl mercuric phosphate (Lignasan X) and C.P. phenylmercuric acetate (Merfenel) (*2*). Later, the method was used in a quantitative determination of the biological activity of Lignasan X in a groundwood mill system. The mill experiments were designed to study the effect of different dosage rates of Lignasan X. In order to obtain the necessary standards, the initial work was conducted in the laboratory, using water solutions of the toxicant. Fresh solutions were prepared for each trial. In the case of Lignasan X, a 1.0% stock solution was prepared and the desired concentrations were obtained by making the proper dilutions. A 0.1% stock solution of phenylmercuric acetate was prepared. All the solutions were prepared with freshly boiled distilled water.

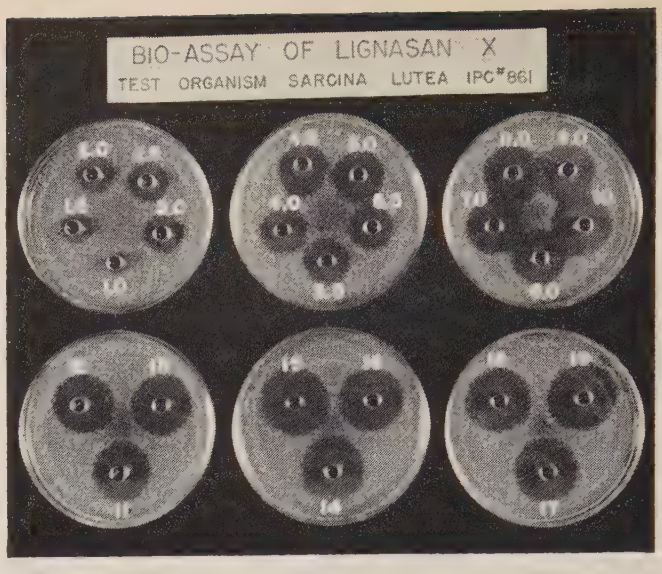

Fig. 1

The plates in Fig. 1 after 24 hours of incubation at 37°C. show the zones of inhibition for the different concentrations of Lignasan X. It can be seen that the zone of inhibition for 1.0 p.p.m. of Lignasan X is practically nil. However, an appreciable zone is obtained with 1.5 p.p.m. of the toxicant. The diameters of the various zones of inhibition are tabulated in Table I. The average of the experimental values and the corrected values can be obtained from the graph in Fig. 2.

Table I. Actual and Corrected Zones of Inhibition for Each Concentration of Lignasan X

Lignasan X, p.p.m.	*Diameter of zone, ml.*	
	Average actual value	*Corrected value*
1.0	8.4	7.4
1.5	9.9	10.1
2.0	12.1	11.9
2.5	12.8	13.4
3.0	14.0	14.6
3.5	15.3	15.5
4.0	16.1	16.4
4.5	17.1	17.1
5.0	18.0	17.9
6.0	19.0	19.0
7.0	19.9	19.9
8.0	20.9	20.8
9.0	21.7	21.5
10.0	22.1	22.3
11.0	22.7	22.9
12.0	23.7	23.5
13.0	23.9	23.9
14.0	24.4	24.5
15.0	25.0	25.0
16.0	25.2	25.3
17.0	25.7	25.7
18.0	25.9	26.0

The actual values plotted on the graph are the averages of 20 separate determinations or the result of 10 separate determinations run in duplicate. The same procedure was followed in obtaining a straight line relationship for the C.P. grade of phenylmercuric acetate. The averages of the plotted experimental values and the corrected values are given in Table II. These data are expressed graphically in Fig. 3.

MILL STUDIES

Because the method of analysis showed promise in the laboratory, it was decided to determine the prac-

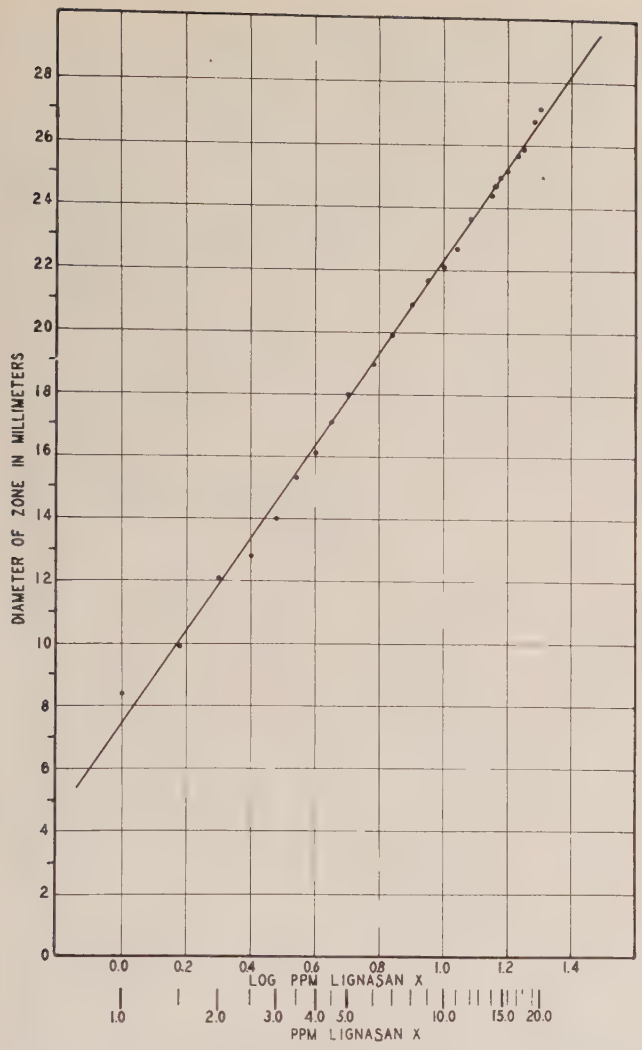

Fig. 2. A straight-line relationship of the zone of inhibition to the concentration of Lignasan X.

ticability of determining the biological activity of a slime control agent in a groundwood mill system. During our study on slime control in a groundwood mill (*1*), variations in the application of Lignasan X were used and the described method of analysis was used in determining the amount and duration of biologically active Lignasan X. This determination was made at two points in the mill system: (1) the white water return line at the grinder and (2) at the sand settler. As shown in the flow sheet (Fig. 4), the sand settler is located in the mill system just before the stock is thickened and the consistency at this point is about 0.8 to 1.0%. The white water at the grinder was sampled at a point in the mill system which gave the greatest dilution of the toxicant. Thus, it was possible to determine the amount of biologically active Lignasan which recirculated in the mill system. The Lignasan X was added to the mill system by placing the required number of Lignasan X packets into one of the pockets of the grinder.

The length of time that Lignasan X was biologically active was determined once each day for a period of two weeks for two treatments. Treatment A was an hourly addition and treatment B was a slug method of treatment. In the hourly addition, five 4-ounce packets were placed into the grinder pocket. In the slug method, Lignasan X was added once every 6 hours at the rate of 0.5 pound of Lignasan X per ton of wood ground. The samples for the determination of biologically active Lignasan were collected at 5-minute intervals for 2 hours at the two sampling points. At the start of the A treatment in a clean mill system, biologically active Lignasan X was detected at the sand settler 20 to 25 minutes after the first addition and was detected in the white water at the grinder 40 minutes after the initial addition. During the first day of treatment the maximum amounts of Lignasan X detected were 12.5 p.p.m. at the sand settler and 2 p.p.m. in the white water at the grinder. Maintaining the same groundwood production and the same hourly addition of Lignasan X, it was found that, on the second day, the residual persisted at the sand settler for only 10 minutes and only to the extent of 1.5 to 3 p.p.m. No biologically active Lignasan X was found in the white water at the grinder. This same pattern was found on the third day. The fourth day, after the regularly scheduled clean-up, biologically active residuals were again detected at the sand settler 20 minutes after the initial addition and persisted throughout the day. Again, on the day following the clean-up, the residuals persisted for only 10 minutes in the sand settler and were not detected at the white water at the grinder. Treatment B, which is a slug method of addition, consists of adding 2.5 pounds

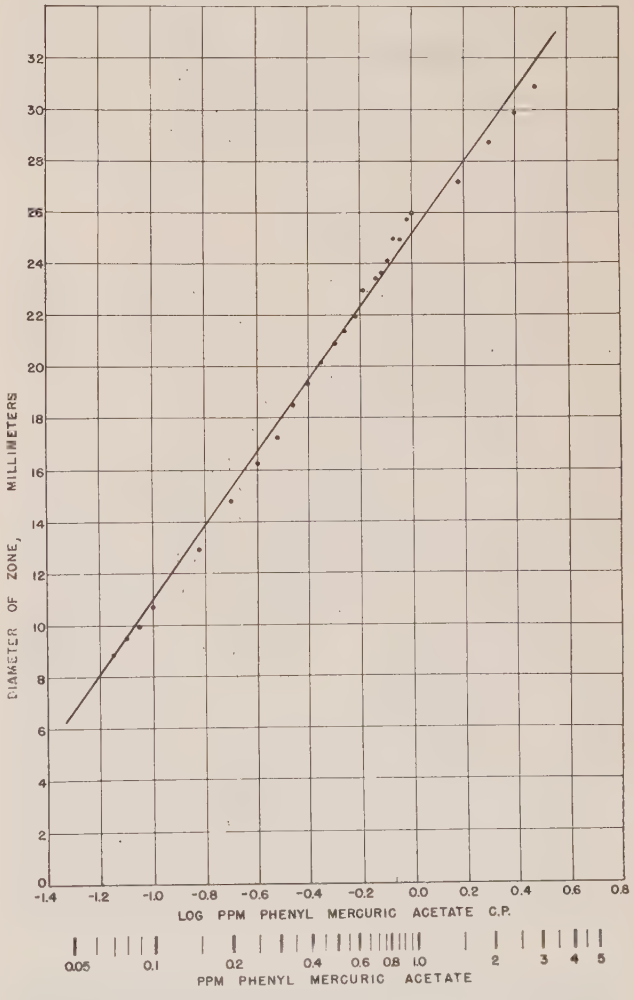

Fig. 3. A straight-line relationship of the zone of inhibition to the concentration of c.p. phenylmercuric acetate

Table II. Actual and Corrected Zones of Inhibition for Each Concentration of C.P. Phenylmercuric Acetate

Phenylmercuric acetate, p.p.m.	*Diameter of zone of inhibition, ml.* Average actual value	Corrected value
0.07	8.9	8.9
0 08	9.5	9.6
0.09	9.9	10.3
0.10	10.7	11.0
0.15	12.9	13.5
0.20	14.7	15.2
0.25	16.2	16.6
0.30	17.2	17.8
0.35	18.5	18.6
0.40	19.3	19.5
0.45	20.1	20.1
0.50	20.9	20.9
0.55	21.4	21.5
0.60	21.9	22.0
0.65	23.0	22.5
0.70	23.4	23.2
0.75	23.6	23.4
0.80	24.1	23.7
0.85	25.0	24.1
0.90	24.9	24.4
0.95	25.7	24.8
1.0	25.9	25.1
1.5	27.2	27.7
2.0	28.7	29.4
2.5	29.9	30.8
3.0	30.9	31.9

of Lignasan X to the grinder pocket once at the beginning of each 6-hour shift. Again immediately after a wash-up, biologically active residuals of Lignasan X persisted throughout the day (Monday) at the sand settler and at the white water at the grinder. As was expected, these residuals were of a greater magnitude than those which were detected when $1^1/_4$ pounds of Lignasan X were added hourly. On Tuesday the residuals persisted for 30 minutes at the sand settler and for 10 minutes in the white water at the grinder. The pattern was repeated after another wash-up.

DISCUSSION

This method of bioassay is very sensitive in that concentrations as low as 1.5 p.p.m. of Lignasan X can be detected. In the case of Merfenel the minimum amount which can be detected is 0.07 p.p.m. A difference of 0.01 p.p.m. can be detected in the low concentrations. This method indicates only the amount of biologically active material and the value may or may not represent the total amount of chemical present. In slime control it is important to be able to determine the amount of biologically active toxicant present in a mill system. It is also equally important to be able to trace the course of a given toxicant. A proper application of the described bioassay method will supply data giving the amount of biologically active toxicant present and also enable one to detect its presence at various points in the system. Also, the compatability of specific toxicants in a given mill system can be determined. Thus, this method gives information that is useful in determining the dosage rate of a given toxicant and the operator is able to vary the initial dosage to conform to the demand of the various materials in the mill system. He is also able to maintain a lethal dose of the toxicant for the required period of time.

With the possible exception of steel cylinders, this method of analysis does not require equipment which is not normally found in a bacteriological laboratory.

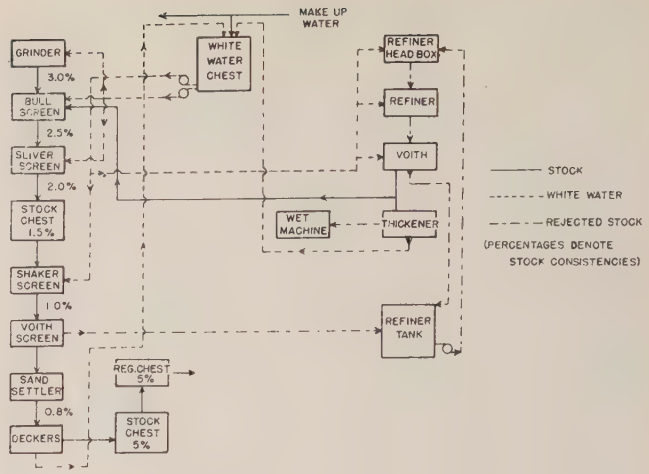

Fig. 4. Flow sheet of the groundwood mill used in this study

The method is relatively rapid and does not require an expert bacteriologist. However, care should be taken in the preparation of the seeded agar and the maintenance of the stock culture. Results are obtainable in 18 to 24 hours, whereas the chemical method of analyzing the toxicant is usually a tedious and time-consuming operation. The chemical method gives the total amount of toxicant present which is not necessarily a measure of its biological activity, whereas the bioassay method gives only the amount of mercury which is biologically active.

The studies reported in this article have been sponsored by the Biological Control Committee of the American Paper and Pulp Association as a part of the fundamental microbiological research program conducted for the paper industry at The Institute of Paper Chemistry. The preliminary phase of this study was sponsored by the Hamilton Laboratories of Asheville, N. C., to whom the authors are very grateful for permission to publish this procedure.

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DISCUSSION

Stanley J. Buckman (President, Buckman Laboratories, Inc., Memphis, Tenn.): The paper presented by the authors is a worth-while contribution to the knowledge of certain phases of microorganism control. It represents a large amount of carefully conducted laboratory work. Although the results of the work of King (*3*) in the United States, Brown and Harrison (*1*) in England, Pehrson and Lindberg (*4*) in Sweden, those reported in the present paper and those which have been obtained in our laboratories, are not all in agreement in either degree or kind, the reasons for the difference undoubtedly will be found as further work is done. In the meantime, many of us properly have the problem of interpreting the results in terms of their significance in practical industrial microorganism control. Viewed in this light, it seems we should

carefully consider the meaning of the term "biologically active" as we use it in our discussions and writings. What is its true meaning?

At least a part and very likely the major part of what we are referring to as "inactivation" seems to be a quite typical adsorption relationship. It thus is pertinent to review some of the characteristics of the phenomenon of concentration at an interface which is called adsorption. In other words, review some of the factors influencing the degree to which a portion of the ethylmercuric and phenylmercuric ions are adsorbed on the surface of the pulp fibers. In this regard, it probably also should be mentioned that the restriction of the paper presented and the following to organomercuric compounds does not mean that comparable relationships do not exist for the chlorinated phenols and other toxicants:

1. Adsorption is an equilibrium and true adsorption shows all of the characteristics of a reversible reaction.

For any given set of conditions, a plot of the logarithm of the amount adsorbed per gram of adsorbent against the logarithm of the concentration gives a straight line, i.e., the relationship is linear. However, variation of any one of a number of conditions, such as pH, general ionic environment, temperature, etc., will change the amount adsorbed. What does this potentially mean in terms of the amount of "biologically active" organomercuric ion present? Two examples may be cited which seem significant and properly raise questions rather than answer them:

A. If we take a suspension of fibers and water, add phenylmercuric acetate to it, allow time for equilibrium adsorption, separate the fibers from the water by centrifuging and determine the amount of organomercuric ion remaining in the fiber-free water by the bioassay method described, we find that a substantial amount of the phenylmercuric ion has been adsorbed by the fibers. In other words, there is a reduction in amount of "biologically active" organomercurial as indicated by the particular procedure.

On the other hand, if we do not separate the fibers and water in a suspension containing the same amount of organomercurial but transfer both the fibers and water to the stainless steel cylinders on the surface of the agar, we obtain inhibition zones which would indicate that there is no adsorption of organomercurial by the fiber. In other words, the inhibition zones are the same within the limits of experimental error as those obtained with a solution of the same concentration of organomercurial without any pulp fibers present. In still other words, the result is one indicating that all of the organomercurial is "biologically active." Bringing the fibers in contact with the agar apparently resulted in a transfer of all or essentially all of the organomercurial adsorbed on the fibers to the agar. This seems to be an example of a major shift in adsorption equilibrium as the result of a change in conditions.

B. Another illustration can be obtained by preparing two liquid culture media, one containing 1% of pulp fibers and the other without pulp fibers or other comparable adsorbents. If we use these two media to prepare two series of culture flasks, add varying amounts of phenylmercuric acetate to each series, and inoculate with *Aspergillus niger*, we find that the growth is inhibited by the same concentration of the organomercurial in each series of cultures. Apparently, the growth of this quite commonly occurring organism creates conditions which result in essentially all of the organomercurial being "biologically active" even in the presence of 1% of pulp fibers. Does a similar situation occur when the mixed flora of bacteria, molds, and various other types of organisms start to grow in accumulations of fine fibers which have an organomercuric ion adsorbed on their surfaces in a temporarily "biologically inactive" state?

2. Adsorption reactions are characterized by a negative temperature coefficient.

The reduction in adsorption as temperature increases probably is due to the increased kinetic energy of molecules with an increase in temperature. Irrespective of the cause, it is clear that temperature must be considered. For example, if one takes a sample from a pulp or paper system containing fibers and allows it to cool before testing it, the amount of adsorption will change.

3. Adsorption reactions are influenced by pH and other changes in the general ionic environment.

The work of Pehrson and Lindberg (*4*) in Sweden and a large amount of work which has been done in our laboratories strongly emphasizes that the general type of adsorption reaction which we are considering here is truly an equilibrium. It may be greatly altered by variations in pH and ionic environment in general. What happens, therefore, when we transfer white water containing fine fibers at one pH to the surface of agar at another pH? It seems very probable that we do not necessarily determine the amount of "biologically active" organomercurial present in the white water as it existed in the mill system.

In addition to the points noted, it seems we also should recognize that the method itself involves the introduction of an adsorbing material which is foreign to pulp and paper mill systems. In other words, the Difco nutrient agar is an adsorbing material which can potentially "inactivate" toxicants and the relationships do not necessarily parallel those which are exhibited by pulp fibers. Large differences are known to exist in adsorptive behavior between much more closely related adsorbents. In fact, Effront (*2*) found that the adsorption of pepsin by filter papers from different manufacturers varied from 0 to 100%. Moreover, neither the ash content nor any chemical analyses of the papers accounted for their different adsorptive characteristics.

Another point which we probably should consider is the fact that the method involves speed of diffusion of an organomercurial in an agar gel in addition to considerations of the amount of organomercurial present. If there is anything in the mill water tested which would reduce the speed of diffusion of the organomercurial so that the maximum amount of diffusion was not obtained before the *Sarcina lutea* developed on the surface agar, the result would be interpreted as a lower amount of "biologically active" organomercurial in the mill water. However, the observed result could be caused by a reduction in the speed of diffusion rather than the amount of "biologically active" organomercurial.

In summary, it seems we should clearly recognize that the determination of the amount of "biologically active" toxicant in mill systems is a very complex problem. The method described in the present paper and similar methods reported by other workers are only a start on what probably will be a long road. We thus should continue to very critically review the data assembled by any method. We should constantly remind ourselves that the results do not necessarily provide even relative indications of the amount of "biologically active" toxicant in the mill systems. Unless we do this, we can lengthen rather than shorten the time necessary to develop a reliable method or methods for such determinations.

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Lengths of Hardwood Fibers and Vessel Segments

A Statistical Analysis of Forty-Nine Hardwoods Indigenous to the United States

STUART I. BERGMAN

The variations exhibited by fibrous elements of both hard and softwoods are discussed. Statistical constants for each of the samples studied as well as segregation of kinds of woods into length classes for fibers and vessel segments are presented. The difference between the means for fiber and vessel-segment lengths of two samples from like kinds of wood may be greater than the corresponding difference for two samples from unlike kinds of wood. No unique mean and standard deviation for fiber and vessel-segment lengths for a particular kind of wood can be correctly presented without a critical analysis of variance based on an extensive sampling. A high degree of positive correlation between the lengths of fibers and those of the vessel segments exists.

CONSIDERABLE research has been undertaken to develop suitable methods for the utilization of the wood fibers of angiospermous trees in the production of pulp and paper. Although the chemical and engineering aspects of this problem have received considerable attention in various laboratories, there is a definite dearth of accurate information on the physical dimensions of the fibers and vessel segments that together compose the ultimate cellular units of hardwood pulp. For the most part such data as are available have not been subjected to critical statistical analysis. This study of the lengths of the elements of domestic hardwoods of interest to the papermaker was, therefore, undertaken in the hope that it would provide pertinent information to bridge the gap in the literature that has heretofore existed.

Variation in dimensions of fibrous elements is the rule, not the exception; this holds not only for the woods of different trees but for the wood of a given kind of tree, in fact for the wood of an individual tree irrespective of kind. Although this paper deals primarily with hardwood fibrous elements (libriform fibers and fiber tracheids), a review of those factors characteristic of coniferous woods which may throw light upon the significance of fiber length variation should not be neglected.

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FACTORS INFLUENCING FIBER LENGTH IN TREES

Fiber Length in Relation to Position in the Coniferous Stem and the Ring-Count from the Pith. The first intensive investigation of fiber (tracheid) lengths was made by Sanio (*10*) who studied the variation in the wood of Scots pine (*Pinus sylvestris* L.). The results of his research demonstrated that five generalizations with respect to length could be formulated. These were:

1. In the stem- and branch-wood, the length increases from the pith (*O*, Fig. 1) outward at a given level until a definite size is reached (M_0). Beyond this point (M_0 to C_0), the average length remains constant.
2. The final sizes attained by the tracheids increase along the bole from L_0 to L_5 at which level a maximum is attained. Their length then decreases from L_5 to L_n. The position of L_5 is dependent upon the age and kind of tree in which the tracheids are formed.
3. The sizes of the mature tracheids of the branch-wood are smaller than are the corresponding cells in the trunk.
4. Irregularities in the variation with respect to the lengths of tracheids which are absent in normal branches occur in gnarled branches at the tops of trees.
5. In the root, there is an increase in tracheid length from the pith outward.

Since the last three generalities just mentioned are concerned with lengths of tracheids in roots and branches, they are not applicable to this investigation; they are included in order that Sanio's suggestions may be a matter of record.

Shephard and Bailey (*12*) disagreed with Sanio with respect to his first generality, but they held that his second was valid; their results indicated that maximum fiber length occurs at a greater distance from the pith in successively higher levels, as indicated by M_0, M_1, M_2,—M_n (Fig. 1).

Gerry (*4*) in studies of fiber lengths of eastern white

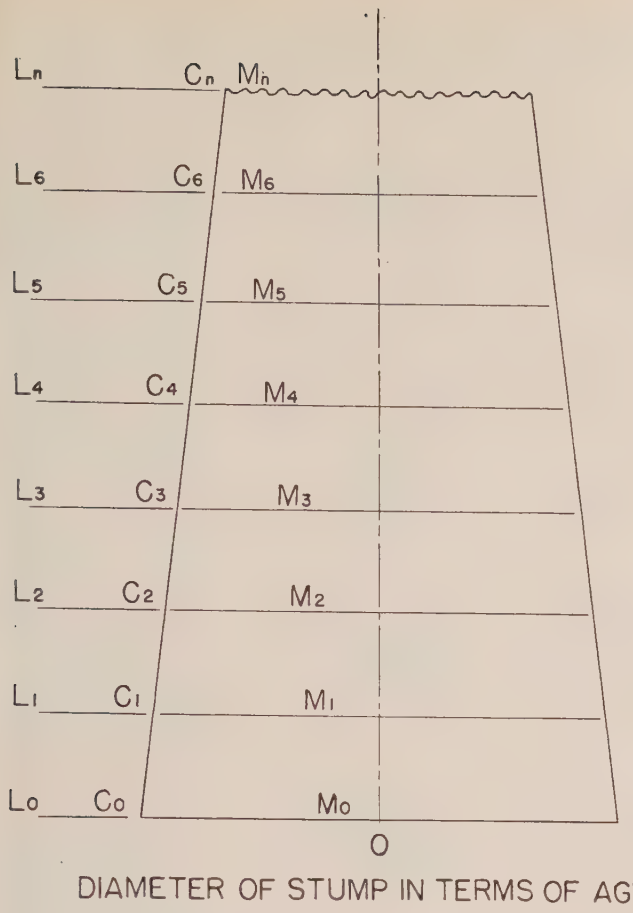

Fig. 1. Graphic presentation of maximum fiber lengths M, in relation to elevation L, and distance of bark from pith C

pine (*Pinus strobus* L.), loblolly pine (*Pinus taeda* L.), longleaf pine (*Pinus palustris* Mill.), and Douglas fir [*Pseudotsuga taxifolia* (Poir.) Britt.], concluded that fiber length increases with increasing ring-count as measured from the pith. It should be noted that the age of a tree *per se* is not necessarily a criterion upon which variation in fiber length can be evaluated; position in the stem is generally far more important. Gerry offered further evidence substantiating the contention that fibers increase in length at successively higher levels until a maximum is reached (L_0 to L_5).

Lee (*6*), as a result of measurements of black spruce [*Picea mariana* (Mill.) B.S.P.] fibers, concluded that at any given level in the tree the lengths of tracheids increase from the pith outward to the bark, (O to *C*). In this gradient, the rate of increase near the pith is more rapid than it is nearer to the periphery of the stem. Lee further demonstrated that fiber length and tree height exhibit positive correlation with respect to fibers from the lower levels of the stem (bole). A maximum length is attained at some height level beyond which a negative correlation prevails.

Kribs (*5*) made comparable observations on the fiber lengths of jack pine (*Pinus banksiana* Lamb.). He noted that the point of maximum length, at successively higher levels, occurs in rings that are progressively nearer to the bark, as is indicated by M_0 to M_n in Fig. 1.

Bethel (*1*), working with loblolly pine, applied statistical methods to an analysis of fiber lengths in terms of age of the tree and position in the stem. The results of his study showed agreement with Sanio's first two postulates. They also agreed with the results obtained by other investigators who found that maximum fiber length within any cross section increases progressively from the base of the tree upward.

Fiber Length in Relation to the Suppression of Coniferous Trees. In a research that was concerned with the affect of suppression on fiber length, MacMillan (*7*) found that the fiber length in the wood of trees growing under unfavorable conditions increases relatively faster during the early development of the tree than in thrifty trees. When such trees were mature, he observed that this relationship was reversed.

Fiber Length in Broad-Leaved Trees in Relation to Height and Ring-Count from the Pith. That variations in the lengths of the fibers and vessel segments similar to those in the tracheids of coniferous trees, occur in the wood of broad-leaved trees was demonstrated by the work of Prichard and Bailey (*9*). They compiled data on the lengths of the fibers and vessel segments from various parts of the stem of shagbark hickory [*Carya ovata* (Mill.) K. Koch]. As a result of their studies, they concluded that the lengths of fibers and vessel segments fluctuated at a given level more or less during the latter stages of the development of the tree; also that the average length of the elements in any given growth increment is not constant since it varies at different heights in the stem.

SOURCE AND SELECTION OF MATERIAL

The data presented in this paper are based specifically on length measurements of the fibers and vessel segments of 49 hardwoods. The wood in every instance was obtained by 125 samplings of trees of authenticated origin. The specifications in addition to authentication as to genus and species were that the stock should come from mature trees at a sufficient distance from the pith so that the fibers have approached their maximum average length. The radius of curvature of the growth increment was employed as a criterion of radial position within the stem. The variations in fiber length resulting from sampling at different tree heights, were minimized by selecting material only from butt logs.

The samples came from three distinct sources, viz:

1. The Project I Collection of the Department of Wood Technology at the New York State College of Forestry. The identifications of the woods from this source are authenticated by voucher-herbarium material from the identical tree, identified by H. P. Brown of the New York State College of Forestry and subsequently checked by A. Rehder of the Arnold Arboretum.

2. The General Wood Collection of the Department of Wood Technology at the New York State College of Forestry. These samples, although not vouchered in toto by herbarium material, nevertheless, were identified by botanists and wood technologists at universities, museums, herbaria, and research laboratories in various parts of the world.

3. The collection of basswood (*Tilia americana* L. and *T. heterophylla* Vent.) samples from Carl de Zeeuw of the New York State College of Forestry.

Table I. Statistical Constants for the Lengths of Fibers and Vessel Segments, Forty-Nine Indigenous Hardwoods

Kind of Wood (2)		Fibers		Vessel segments	
Common name	Scientific name	λ_f, mm.	σ_f, mm.	λ_v, mm.	σ_v, mm.
1. Alder, red	*Alnus rubra* Bong.	0.89	0.22	0.79	0.09
		1.28	0.22	0.90	0.11
2. Ash, black	*Fraxinus nigra* Marsh.	0.89	0.19	0.24	0.06
		0.90	0.26	0.25	0.05
3. Ash, white	*Fraxinus americana* L.	1.03	0.35	0.31	0.06
		1.17	0.20	0.29	0.05
4. Aspen, bigtooth	*Populus grandidentata* Michx.	1.03	0.21	0.61	0.07
		1.05	0.25	0.66	0.15
		1.09	0.23	0.75	0.20
5. Aspen, quaking	*Populus tremuloides* Michx.	0.74	0.16	0.45	0.08
		0.99	0.25	0.71	0.13
		1.07	0.22	0.68	0.13
		1.35	0.26	0.65	0.11
6. Basswood	*Tilia americana* L.	0.97	0.18	0.37	0.05
		1.11	0.14	0.71	0.19
		1.30	0.23	0.40	0.06
7. Basswood, white	*Tilia heterophylla* Vent.	1.10	0.26	0.48	0.07
		1.16	0.23	0.48	0.07
		1.22	0.23	0.47	0.06
8. Beech	*Fagus grandifolia* Ehrh.	1.07	0.20	0.51	0.08
		1.11	0.31	0.56	0.09
		1.12	0.25	0.57	0.10
		1.42	0.36	0.66	0.11
9. Birch, black	*Betula lenta L.*	1.31	0.23	0.84	0.17
		1.41	0.27	1.04	0.16
		1.41	0.30	0.90	0.20
10. Birch, gray	*Betula populifolia* Marsh.	0.90	0.25	0.69	0.17
		0.91	0.22	0.59	0.14
11. Birch, paper	*Betula papyrifera* Marsh.	1.25	0.23	0.97	0.16
		1.39	0.34	0.90	0.18
		1.41	0.31	0.97	0.18
12. Birch, river	*Betula nigra* L.	1.15	0.19	0.27	0.05
		1.18	0.21	0.72	0.14
13. Birch yellow	*Betula lutea* Michx, f.	1.15	0.26	0.74	0.16
		1.25	0.33	0.91	0.17
		1.37	0.36	0.91	0.22
		1.40	0.33	1.18	0.18
14. Buckeye, yellow	*Aesculus octandra* Marsh.	0.82	0.07	0.50	0.06
		0.83	0.16	0.41	0.05
15. Butternut	*Juglans cinerea* L.	1.04	0.24	0.53	0.11
		1.28	0.22	0.57	0.08
16. Catalpa, northern	*Catalpa speciosa* Ward.	0.62	0.12	0.22	0.05
		0.68	0.14	0.26	0.06
17. Cherry, black	*Prunus serotina* Ehrh.	0.75	0.24	0.48	0.10
		0.78	0.23	0.38	0.09
18. Chestnut	*Castanea dentata* (Marsh.) Borkh.	0.99	0.22	0.56	0.16
		1.04	0.23	0.58	0.13
19. Cottonwood, eastern	*Populus deltoides* Bartr.	0.98	0.20	0.62	0.10
		1.26	0.29	0.66	0.11
20. Cottonwood, northern black	*Populus trichocarpa var. Hastata* Henry	1.02	0.24	0.68	0.13
		1.03	0.20	0.74	0.13
		1.09	0.24	0.64	0.11
		1.16	0.26	0.82	0.11
21. Cucumber-tree	*Magnolia acuminata* L.	1.37	0.28	0.71	0.11
		1.44	0.32	0.73	0.13
22 Dogwood	*Cornus florida* L.	1.41	0.34	0.99	0.20
		1.45	0.37	1.06	0.20
23. Elm, american	*Ulmus americana* L.	1.21	0.31	0.30	0.06
		1.30	0.28	0.27	0.04
		1.41	0.23	0.27	0.04
24. Elm, rock	*Ulmus thomasi* Sarg.	1.11	0.29	0.20	0.02
		1.13	0.31	0.26	0.04
		1.17	0.22	0.22	0.03
25. Elm, slippery	*Ulmus fulva* Michx.	1.17	0.28	0.30	0.06
		1.39	0.26	0.28	0.05
26. Gum, black	*Nyssa sylvatica* Marsh.	1.58	0.35	1.02	0.29
		1.83	0.63	1.21	0.32
		1.87	0.41	1.15	0.23
		2.01	0.47	1.25	0.25
27. Gum, tupelo	*Nyssa aquatica* L.	1.79	0.37	1.11	0.20
		1.83	0.38	1.12	0.20
		1.84	0.30	1.29	0.25
28. Hackberry	*Celtis occidentalis* L.	0.67	0.13	0.34	0.09
		1.16	0.20	0.25	0.05
29. Hickory, mockernut	*Carya tomentosa* (Poir.)	1.18	0.26	0.43	0.13
		1.40	0.23	0.50	0.10
30. Hickory, shagbark	*Carya ovata* (Mill.) K. Koch	1.06	0.26	0.42	0.12
		1.13	0.22	0.43	0.10
31. Holly	*Ilex opaca* Ait.	1.25	0.39	0.91	0.18
		1.52	0.35	0.91	0.18
32. Locust, black	*Robinia pseudoacacia* L.	0.90	0.20	0.19	0.03
		0.99	0.22	0.17	0.03
33. Magnolia, evergreen	*Magnolia grandiflora* L.	1.54	0.30	0.89	0.15
		1.56	0.34	0.87	0.15
		1.72	0.25	1.03	0.18
		1.80	0.31	1.03	0.18
34. Maple, red	*Acer rubrum* L.	0.79	0.18	0.46	0.10
		0.80	0.16	0.51	0.08
		0.83	0.16	0.49	0.08
		0.87	0.15	0.47	0.08
35. Maple, silver	*Acer saccharinum* L.	0.62	0.11	0.49	0.06
		0.86	0.17	0.51	0.08
36. Maple, sugar	*Acer saccharum* Marsh.	0.71	0.14	0.30	0.04
		0.71	0.14	0.31	0.07
		0.76	0.18	0.31	0.05
		0.78	0.14	0.34	0.07
37. Mulberry, red	*Morus rubra* L.	0.79	0.24	0.20	0.04
		0.86	0.18	0.18	0.05
38. Persimmon	*Diospyros virginiana* L.	1.15	0.31	0.39	0.04
39. Poplar, balsam	*Populus tacamahaca* Mill.	0.91	0.24	0.57	0.12
		0.95	0.22	0.45	0.10
		1.12	0.23	0.59	0.12
40. Red-bay	*Persea borbonia* Spreng.	0.99	0.15	0.39	0.07
41. Red-gum	*Liquidambar styraciflua* L.	1.42	0.29	1.02	0.20
		1.47	0.34	1.07	0.31
		1.72	0.33	1.18	0.26
		1.72	0.28	1.41	0.29
42. Oak, black	*Quercus velutina* Lam.	1.31	0.31	0.49	0.08
		1.44	0.39	0.55	0.10
43. Oak, northern red	*Quercus borealis* Michx. f.	1.37	0.29	0.45	0.11
		1.42	0.32	0.53	0.10
44. Oak, white	*Quercus alba* L,	1.08	0.33	0.51	0.18
		1.10	0.18	0.52	0.13
		1.23	0.23	0.56	0.11
		1.58	0.29	0.57	0.15
45. Sassafras	*Sassafras albidum* (Nutt.) Nees.	0.83	0.20	0.41	0.07
46. Sycamore	*Platanus occidentalis* L.	1.51	0.32	0.57	0.14
		1.66	0.29	0.73	0.12
47. Walnut, black	*Juglans nigra* L.	1.25	0.26	0.53	0.07
48. Willow, black	*Salix nigra* Marsh.	1.19	0.28	0.64	0.12
		1.19	0.29	0.65	0.12
49. Yellow-poplar	*Liriodendron tulipifera* L.	1.31	0.27	0.75	0.11
		1.36	0.23	0.81	0.11
		1.59	0.32	0.87	0.12
		1.73	0.36	0.86	0.11

These samples were likewise vouchered by herbarium material in every instance.

Whenever possible, four samples, from different trees, were selected for each statistical analysis. For those kinds of wood that are now important in the paper industry, every effort was made to secure this quota. On the other hand, a smaller number was considered to be sufficient for those woods which are of minor industrial importance. Owing to limitations of time, no more than four samples of any one kind of wood were studied. It was felt that the additional refinement gained by analyses of a larger number was not warranted.

PREPARATION AND EXAMINATION

The maceration of the wood was accomplished by the Schultze method (*11*). According to this technique, a small sample of wood was split into segments approximately of matchstick size. They were then placed in water-filled vials and aspirated to remove the included air during which process the cell cavities became completely filled with water. The vials containing the water-logged segments were drained of excess water, refilled with a mixture of concentrated nitric acid and potassium chlorate, placed under a ventilating hood and allowed to stand at room temperature until the chips were bleached. The fluid in the vial was then decanted from the delignified material; several changes of tap water were then made to remove all traces of acid. Complete separation of the fibers was accomplished by vigorous shaking in 70%

Table II. Kinds of Woods Included in Fiber Length Classes

Class I (1.80–2.09 mm.)	
Evergreen magnolia	Black gum
Tupelo gum	
Class II (1.50–1.79 mm.)	
Evergreen magnolia	Sycamore
Yellow-poplar	Holly
Red-gum	
Class III (1.20–1.49 mm.)	
Quaking aspen	Red oak
Eastern cottonwood	Black oak
Northern black cottonwood	American elm
Black walnut	Slippery elm
Butternut	Cucumber-tree
Mockernut hickory	Yellow-poplar
Yellow birch	Red-gum
Black birch	Holly
Paper birch	Basswood
Red alder	White basswood
Beech	Dogwood
White oak	
Class IV (0.90–1.19 mm.)	
Black willow	Black locust
Quaking aspen	Basswood
Bigtooth aspen	White basswood
Balsam poplar	Persimmon
Eastern cottonwood	White ash
Northern black cottonwood	Black ash
Butternut	
Class V (0.60–0.89 mm.)	
Red mulberry	Silver maple
Sassafras	Yellow buckeye
Black cherry	Black ash
Sugar maple	Catalpa
Red maple	

ethyl alcohol. The alcohol was used primarily to prevent fungal attack during storage.

When this phase of the treatment had been completed, a temporary mount of the fiber suspension was made. The lengths of approximately 25 fibers and 10 vessel segments were determined by measuring the images projected on a ground glass screen using a microprojector and a calibrated flexible rule. The measurements included the tips of the fibers and vessel segments. To prevent measurement of the same element twice, a mechanical stage and a standard pattern of motion were employed. Four such slides for each sample were prepared and comparable sets of measurements were made. This resulted in a total of approximately 100 fiber and 40 vessel-segment measurements for each sample studied. Special care was exercised to insure random selection insofar as broken or intermingled masses of fibers and vessel segments permitted. All fibers were measured to the nearest tenth of a millimeter; comparable limits for vessel segments were from one tenth to five-hundredths of a millimeter depending upon the degree of variation in length exhibited by the particular sample studied.

The data obtained by this method were treated by standard statistical techniques (*3*). The mean and standard deviation were calculated for the fibers and vessel segments, respectively, of each sample of wood studied.

DISCUSSION OF RESULTS

The results obtained from this study are of interest both from a practical and an academic standpoint. It was realized from the beginning that it would be impossible to obtain significant general average fiber and vessel-segment lengths for each kind of wood studied. The degree of variability within each individual tree, not only with respect to distance from the pith, but also with respect to height above ground, is so great that a larger number of samples from carefully selected zones and levels would be required to compute a valid composite mean which would have practical significance. Furthermore, trees from many selected habitats and locations within the range of the species concerned would require similar treatment in order to test the constancy of variability with reference to position in the tree as well as locale in which the tree grows. Such a procedure might result in a significant average length of fiber or vessel segment for a specific kind of wood. However, the time involved in the completion of such a study would be out of all proportion to the practical value of the refinement thus obtained. It is for this reason that no attempt has been made to compute the mean and standard deviation for a kind of wood as a whole. Such combined statistical constants, if calculated, might prove to be misleading; hence, all that has been attempted was to evaluate these constants (the arithmetic mean and the standard deviation) for each sample, the results of which are recorded in Table I. It is hoped that these values, *per se*, will be useful not

Table III. Kinds of Woods Included in Vessel Segment Length Classes

Class I (1.00 or more)	
Yellow birch	Tupelo gum
Black birch	Black gum
Evergreen magnolia	Dogwood
Red-gum	
Class II (0.75–0.99 mm.)	
Bigtooth aspen	Red alder
Northern black cottonwood	Evergreen magnolia
Yellow birch	Yellow-poplar
Black birch	Holly
Paper birch	Dogwood
Class III (0.50–0.74 mm.)	
Black willow	Beech
Quaking aspen	Chestnut
Bigtooth aspen	White oak
Balsam poplar	Northern red oak
Eastern cottonwood	Black oak
Northern black cottonwood	Cucumber-tree
Black walnut	Sycamore
Butternut	Red maple
Mockernut hickory	Silver maple
Yellow birch	Yellow buckeye
Paper birch	Basswood
Black birch	
Class IV (0.25–0.49 mm.)	
Quaking aspen	Black cherry
Balsam poplar	Sugar maple
Shagbark hickory	Red maple
Mockernut hickory	Silver maple
Northern red oak	Yellow buckeye
Black oak	Basswood
American elm	White basswood
Slippery elm	Persimmon
Rock elm	White ash
Hackberry	Black ash
Sassafras	Catalpa
Class V (0.10–0.24 mm.)	
Rock elm	Black ash
Red mulberry	Catalpa
Black locust	

only to show the order of magnitude of fiber and vessel segment lengths for the various kinds of wood, but also to present the degree of variation that might occur.

In studying this variation, it was found that in many cases, the standard error of the difference between the means of two or more samples for one kind of wood suggested that significant statistical differences between these means do exist. This result is to be expected when the possibilities of variation within different parts of the tree and with respect to environment are considered.

Table II represents length classes into which the woods have been segregated according to the most probable average lengths of their fibers. Table III represents exactly the same classification with respect to vessel-segment lengths. In those cases where one test seemed to be decidedly out of line with those of other samples from the same kind of wood or woods of closely related species, they were omitted from their indicated classification.

SUMMARY

1. The difference between the means for fiber and vessel-segment lengths of two samples from like kinds of wood may be greater than the corresponding difference for two samples from unlike kinds of wood.

2. No unique mean and standard deviation for fiber and vessel-segment lengths for a particular kind of wood can be correctly presented without a critical analysis of variance based on a larger sampling than was used in this investigation. Furthermore, samples chosen from various parts of the same tree as well as from trees of the same kind from varying sites and geographical locations should be employed.

3. A high degree of positive correlation (+0.706) between the lengths of fibers and those of the vessel segments exists.

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Scattering and Absorption of Light in Paper and Other Diffusing Media

A Note on the Coefficients of the Kubelka-Munk Theory

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The majority of the optical properties of paper depend for their evaluation on diffuse reflectance which, in turn, is related through the Kubelka-Munk theory to the scattering and absorption coefficients of the paper. The latter have often been employed in studies of the optical properties of paper and other light-scattering media. In the development of their useful theory, Kubelka and Munk have followed the convention of employing distance (x) as the independent variable. In the application of the Kubelka-Munk theory, thickness (X) has not proved to be a convenient quantity; for example, it has usually been found to be expedient to substitute basis weight for X. The awkwardness of X in the theory is illustrated in (1) the apparent change in S and K when density is changed in such manner that the scattering power and absorbing power of a sheet actually does not change, (2) the difficulty of relating formulas, based on weights of the components, with X, and (3) the difficulty of relating the absorption coefficient of coloring matter in solution with the contribution of such coloring matter to the calculated absorption coefficient of pulp or paper. It is shown that the differential equation on which the Kubelka-Munk theory is based can be replaced with one that is mathematically equivalent, but in which S and K are replaced with, respectively, the *specific scattering coefficient* (s) and the *specific absorption coefficient* (k) and in which an infinitesimal increment in distance (dx) is replaced by an infinitesimal increment in weight per unit area (basis weight) (dW). All the relationships of the Kubelka-Munk theory, all tabulations, and all charts remain the same except that W everywhere replaces X, s replaces S, k replaces K, and, in particular, sW replaces SX. It is suggested that new compilations of the theory and new issues of charts be modified in accordance with these simple changes. The advantages of the change in point of view are discussed with illustrative cases.

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Most of the measured optical properties of paper of importance depend upon evaluation of diffuse reflectance. Thus, the evaluation of color requires a determination of spectral reflectance (color curve giving diffuse reflectance against wavelength of monochromatic light) (*1*); the measurement of papermaker's "brightness" involves a determination of a specialized diffuse reflectance for blue light (*2*); and opacity is expressed as a "contrast ratio" of two diffuse reflectances:* either $R_0/R_{0.89}$ (TAPPI opacity) or R_0/R_∞ (printing opacity) (*3*).

In researches on, or involving, these optical properties, questions often arise regarding the connections between the properties and the furnish or the treatment of the paper. Experience has shown that the most valid and generally useful theory of the scattering and absorption of light in paper (and in other light-scattering media) is that developed by Kubelka and Munk (*4*). This theory, especially in the form of the more convenient equations and charts evolved by Steele (*5*) and the well-known Bureau of Standards reflectance-opacity chart (*6*), has been of considerable value. Recently, Kubelka (*7*) has published new contributions to the theory, and presented a number of useful relationships.

An important parameter of the theory (and also a basic optical property of a sheet of paper) is the scattering power, SX. The quantity S is the scattering coefficient of the sheet material, and X is the thickness of the sheet. Another important quantity in the application of the theory is the absorbing power, KX, where K is the absorption coefficient of the sheet material. The ratio $(KX/SX) = K/S$ determines the reflectivity $R\infty$ of the material.* The reflectivity is an intrinsic characteristic of the sheet material and, as such, appears in a number of the relationships of the theory.

The principal point to be made in this paper is that thickness (X) is an awkward variable, and that it is not necessary to invoke this quantity in any phase of the theory. Workers in the field have recognized the inconvenience of employing thickness, and have substituted basic weight for thickness. For example, SX and KX have been divided by W, the basis weight, to obtain, respectively, the "scattering coefficient" and the "absorption coefficient," with "basis weight substituted for X." One of the reasons which has been advanced for this practice is that basis weight is more accurately known than thickness.

The practice referred to in the foregoing paragraph is a good one. However, even if it were possible to evaluate thickness with great accuracy, the use of thickness in the application of the theory would remain awkward. This can be made clear in a few examples. Let us consider a dry sheet of paper having scattering power SX. If this sheet be subjected to dry compression, so that its thickness is reduced to, say, 0.9 of its original value, we would find, under ordinary circumstances, that SX had not changed; however, the scattering coefficient would be found to have a value of about 1.11 of the original value. Similar comment could be made about the absorbing power and the absorption coefficient. In another example, we may consider the problem of studying the scattering and absorption coefficients of the fibrous and nonfibrous components of paper. In the past, this has been correctly done by equating the scattering coefficient of the sheet (obtained by dividing SX by W) to the weight average of the coefficients of the components, in which the weighting factors are based on weights in the furnish, and the individual coefficients are, again, of the form SX/W. Absorption coefficients have been handled in an exactly analogous manner. The confusion which would arise in this important application of the theory if one attempted to deal with thickness instead of basis weight is self-evident. In a third, very interesting example, we may consider the relationship between the color of paper (or pulp) and the color of an extractable material, or, conversely, we might add a coloring matter to fiber and inquire about the theoretical effect of such coloring matter on the final color of the fiber. In such studies, it is usually desirable to evaluate the color of a soluble material in solution, using a suitable spectrophotometric method for the determination of the spectral absorption coefficient of the material. Here, the well-known exponential law of absorption of light applies: $T = e^{-acx}$, in which T is the transmittance of the solution of thickness x and concentration c and a is the absorption coefficient of the material in solution.† In the experience of the writer, competent technical men are often confused in the matter of relating values of a and K, even when K is obtained through the use of basis weight in place of sheet thickness. One of the purposes of this paper is to clarify this relationship.

In the development of any theory on the absorption and scattering of light in a medium, it is natural (as a consequence of traditional approach) to start with a differential equation involving x, the distance from one surface of the medium to an infinitesimal layer to which the differential equation applies. Thus, in the development of the theory, one imagines the sheet to be arranged horizontally, and to be illuminated from above with diffuse light of intensity I_0. A layer within the sheet of thickness dx is considered. Using the more familiar nomenclature of Steele (*5*), and quoting from his presentation of the Kubelka-Munk development of the basic theory, we have the following treatment. The intensity of light incident on the layer from above (after transmission through the medium above the layer) is i_t; the intensity of light incident on the layer from below (after reflection from the medium below the layer) is i_r. When the light passes through the infinitesimal layer,

"i_t is decreased *by* $i_t\ (S + K)\ dx$, i_r is decreased by $i_r\ (S + K)\ dx$, by definition, where S is the scattering coefficient and K is the absorption coefficient. Similarly, i_t is increased by $Si_r dx$, and i_r is increased by $Si_t dx$. Then

$$-di_t = -(S + K)i_t dx + Si_r dx$$
$$di_r = -(S + K)i_r dx + Si_t\ dx."$$

Certain purely manipulative steps then follow, in which the quotient i_r/i_t is put equal to r. It is shown that

$$"dr = [-2(S + K)r + S + Sr^2]dx$$

$$\int_{R'}^{R} \frac{dr}{r^2 - 2[(S + K)/S]r + 1} = S \int_0^X dx"$$

The integral on the right side of the equation is simply SX. The integral on the left side of the equation is carried out between the limits R', the reflectance of

* R_0 = reflectance of a single sheet backed by a black body; $R_{0.89}$ = reflectance of a single sheet backed by a white body whose absolute reflectance is 0.89 (or 91.5% reflectance relative to MgO); $R\infty$ = reflectance of a single sheet backed by a stack of similar sheets sufficiently thick to be opaque (equivalent to an infinite layer). Some instruments measure the ratios automatically.

† This law, generally known as Beer's Law does not always apply with accuracy. In some cases, there is an appreciable effect of the solvent on the measured value of a and, for a given solvent, a is often observed to vary with concentration. The law is usually assumed as a first step, however, and often proves to be of value.

the backing under the sheet, to R, the reflectance of the sheet when backed with a surface of reflectance R'. Various useful relationships have been derived from the last equation by Kubelka and Munk, Steele, and others.

Basically the same theory, in a form more suitable for application, may be developed without invoking distance and thickness. In the interest of simplicity, our treatment will parallel that of Kubelka and Munk. We visualize the spatial arrangement employed in the foregoing. However, we consider an infinitesimal layer of the material that contains dW weight of material per unit area of the layer. Then when light passes down through the layer, and up through the layer, i_t is decreased by $i_t\ (s + k)\ dW$, and i_r is decreased by $i_r(s + k)\ dW$, where s is the *specific scattering coefficient* and k is the *specific absorption coefficient.** The remaining steps in the theory are mathematically the same as those already quoted. It is only necessary to make the following changes of symbols: S to s, K to k, x and X to W and, in particular, SX to sW. It should be recalled that basis weight is a weight per unit area, so that W may be identified with basis weight. Both SX and sW are pure numbers, and are equivalent. *Wherever* SX *appears in existing equations, tabulations, and charts, one may substitute* sW. It is suggested that new compilations of the theory and new issues of charts be thus simply modified. The units of s and of k are reciprocal basis weight units, and may be anything desired by the individual investigator. For reasons that will be clear later, it is desirable in special applications to employ grams per square centimeter.

Some of the advantages of the simple modification in point of view become readily apparent. If the thickness of dry paper is modified in any manner (as by mild compression) which does not result in the creation or rupturing of particle-to-particle bonding, the basis weight of course remains unaltered, and s and k are not changed. The relationships between s and k of a sheet and the corresponding quantities of the sheet components become clear, and are placed on a sounder footing. Where, in the differential equation (present treatment), we have $s\ dW$ and $k\ dW$, we could write instead $s_1dW_1 + s_2dW_2 + \ldots$ and $k_1dW_1 + k_2dW_2 + \ldots$, respectively, where the subscripts 1, 2, ... designate the sheet components, whose specific coefficients are s_1 and k_1, s_2 and k_2, etc., and dW_1, dW_2, are the contributions of the components to the increment in basis weight dW. The foregoing sums are differentials of the following useful equations:

$$sW = s_1W_1 + s_2W_2 + \ldots$$

$$kW = k_1W_1 + k_2W_2 + \ldots$$

which will not be unfamiliar, in form, to persons who have applied the Kubelka-Munk theory. On dividing both sides of these equations by the total basis weight W, the factors of the specific coefficients on the right side become the fractional weights of the components of the furnish.

We may now consider the problem, to which reference has already been made, of relating the color of an extractive or soluble component in solution to the effect of that component on the color of pulp or paper. In the conventional derivation of the exponential law of absorption of light in a clear (nonturbid) solution, one considers the absorption by a layer of the solution of infinitesimal thickness dx. On passing through this layer, the change in intensity of the light is proportional to the intensity at that point, I, and also proportional to the concentration (c) of the solute and the thickness (dx) of the layers, so that $dI = -aIc\ dx$. This integrates immediately to $I = I_0\ e^{-acx}$, where I_0 is the intensity of the light incident upon the solution, and I is the intensity of the light after transmission through the solution. In this, a, the constant of proportionality, is the absorption coefficient. *Now we may employ the point of view that the change in intensity of light on passing through the layer of infinitesimal thickness is proportional to the "basis weight" or weight per unit area of the solute in the layer,* dW. Of course, $W = cx$, and $dW = c\ dx$. Therefore, $dI = -aI\ dW$ and, on integrating, $I = I_0\ e^{-aW}$, which can be written in the more convenient form, $a = (2.30/W)\ \log_{10}\ (1/T)$, where T is the transmittance of the solution.

Thus, it will be seen that a (absorption coefficient of the solute in solution) is defined similarly to k. We should, however, expect a numerical difference, because a is determined with essentially parallel rays, whereas the light in paper (and in other light-scattering media) is almost perfectly diffuse. In passing through a thin layer, parallel rays actually pass through the exact thickness of the layer, whereas the rays of diffuse light (which are incident on the layer at all angles between zero and 90°) traverse the layer in path lengths that are greater than the thickness—theoretically, the path lengths for diffuse light vary from the layer thickness to infinitely greater than the thickness. Accordingly, the absorption coefficient for parallel rays (a) is less than that for diffuse light (k). It is shown in the appendix that $k = 2a$.

The implication of the foregoing discussion is that one can quantitatively measure the contribution to the color of pulp or paper of an extractive or additive by measuring the variation of $2a$ with wavelength (determined from spectral transmittance of a solution of the extractive or additive). Actually, quantitative results are not generally to be expected, and the reasons for inaccuracy are quite interesting. First, there is a possibility of an effect of the solvent on the color of the material. Second, the material in the fiber (before extraction) may be distributed in a very spotty manner—e.g., concentrated in microscopic regions. When the material is distributed in a heterogenous fashion, its contribution to the color (technically to k) of the fiber is less than when it is uniformly dispersed. A familiar example is afforded by the powdered sugar-dye mixture employed in the dry-indicator size test. When dry, the mixture is almost white; the particles of dye are concentrated in specks and occupy so little volume that few of the light rays strike them. When the mixture becomes wet with water, the dye dissolves and diffuses throughout the system to become more uniformly distributed, and

* In past work, we have designated these coefficients with the symbols S' and K', respectively; it seems desirable to avoid the use of the prime by employing lower case letters.

the mixture becomes very dark in color. A third possibility is that the color of the material may be influenced by the process of sorption to the fiber. In general, the variation of $2a$ with wavelength will be sufficiently similar to that of k of the extractive to be of value in analytical work and, in some cases, the difference between $2a$ and k (if such difference is appreciable) may be of value in estimating the uniformity of distribution of the extractive in its original state in the fiber. In some cases, it might be helpful to compare the k values of the fiber before extraction, of the fiber after extraction, and of the fiber after addition of the extractive to the fiber from solution, because the reintroduction of the extractive to the fiber from solution may result in a more uniform distribution than existed in the original conditions; the value of $2a$ (from data obtained with the solution) should be included in these comparisons.

To return to the principal subject of this article, it seems desirable to suggest that the various workers employing the Kubelka-Munk theory adopt a common unit for basis weight. In this area of work, it is readily seen that the TAPPI unit of basis weight (1 pound per 500,000 square inch) or the metric unit (1 gram per square meter) is inconvenient. When the basis weight is expressed in grams per square centimeter, there is no confusion in correlating absorption coefficients in solids and solutions, and numbers for k and s of convenient magnitude are obtained.

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APPENDIX

Relationship between the absorption coefficient for parallel rays (a_p) and the absorption coefficient for diffuse light (a_d).

Consider a layer of infinitesimal thickness in which the weight of absorbing matter per unit area is dW. Using spherical coordinates, with the angle θ referred to the perpendicular to the layer, the radiant energy incident upon unit area of the layer and confined within the infinitesimal solid angle ($\sin\theta\ d\theta\ d\varphi$), at angle θ is

$$dE = I \cos\theta \sin\theta\, d\theta\, d\varphi, \qquad (1)$$

in which I is an intensity factor. If the light is perfectly diffuse, I is constant and has such value that integration of equation (1) over all angles of a hemisphere yields the energy E incident on unit area; when such integration is carried out, it is found that $I = E/\pi$. For rays passing through the layer at angle θ, the basis weight per unit area normal to the rays is $dW/\cos\theta$ (this is equivalent to $c(dx/\cos\theta)$, where c is the concentration of the absorbing matter). Hence, the loss in energy of the rays passing through the layer is

$$-dE = a_p(dW/\cos\theta)(E/\pi)\cos\theta \sin\theta\, d\theta\, d\varphi.$$

Integrating this expression over all values of φ (from 0 to 2π) and of θ (from 0 to $\pi/2$), one obtains

$$dE = -2a_pE\, dW = -a_dE\, dW,$$

by definition of a_d. It is seen that $a_d = 2a_p$. Integration results in

$$E = E_0\, e^{-2a_pW} = E_0 e^{-a_dW}$$

or the equivalent relations,

$$T = e^{-2a_pW} = e^{-a_dW},$$

where T is the transmittance of the solution.

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The Dry-Indicator Method as a Test for Water Resistance

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Five types of water-resistance tests are briefly described: absorption methods, depth-of-penetration methods, functional-failure methods, initial-transudation methods, and discharge-rate methods. The dry-indicator method belongs to the fourth type which indicates how well a material prevents water from getting through. Although much used, the method has sometimes been severely criticized. The chief criticisms discussed relate to indefinite endpoint, effect of water vapor, blindness to changes that occur after the endpoint, two-sided behavior, and differences in batches of dry indicator. The conventional nomenclature for the resistance of membranes to the passage of fluids, based on the entering phase, is defended. Some published data are cited in support of the validity of the dry-indicator method for measuring the water resistance of paper.

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A number of methods for measuring the water resistance of paper are in use. This property, one soon discovers, consists of several related properties that have to be evaluated by different techniques. Water-resistance tests are usually included among sizing tests of which several dozen have been proposed. However, tests for water resistance comprise a group of tests that may well be considered apart because of sufficient importance in their own right.

The distinction between water-resistance tests and sizing tests is not clearly marked. Sizing tests are used to test water resistance, but they also provide additional information. They are intended to forecast the receptivity of paper to aqueous solutions, and to writing inks in particular. Water-resistance tests are

confined to evaluating the behavior of paper and sheet materials toward water alone. Sizing tests are usually short-period tests, reckoned usually in seconds or minutes, whereas water-resistance tests are more likely to be long-period tests, reckoned perhaps in hours or days. Sizing tests are associated with writing papers and water-resistance tests with case-lining papers. The distinction becomes hazy and overlapping in the region between.

CLASSIFICATION OF WATER-RESISTANCE TESTS

It is convenient to consider water-resistance tests in five groups.

Group 1. Absorption Methods

Method 1.1 The amount of water absorbed by a fairly large surface of the material in a given time is measured by weight difference. The immersion test the Cobb test, and the floating technique as applied to fiberboards are good examples. These methods give an inverse measure of water resistance.

Method 1.2 A single drop of water of known volume, delivered from a pipet or dropper, is placed on the material to be tested, and the time for its disappearance by sorption is measured.

Method 1.3 Water is confined between the specimen and an enclosing surface pierced by a capillary tube. Water absorbed by the specimen is indicated by a corresponding displacement of the water meniscus in the capillary. This method has not worked well with paper, which swells and buckles, because one can not distinguish between change of volume by absorption and change of volume by distortion or displacement of the specimen.

Group 2. Depth of Penetration

Method 2.1 The specimen is sectioned perpendicular to the plane of the sheet after it has been in contact with water for a given time. A water-sensitive indicator applied to the exposed cross section reveals the depth of penetration.

Method 2.2 The specimen (paperboard or other thick material) is sectioned parallel to the plane of the sheet after one surface has been in contact with water for a given time. The moisture content is determined for each of the layers thus obtained, and the data are used in determining the depth of penetration.

Group 3. Functional Failure Resulting from Wetting

Method 3.1 A mechanical failure as a result of wetting is evaluated. Examples of this type of failure are changes in tensile or bursting strength.

Method 3.2 Other types of failure as a result of wetting can be evaluated. Examples of this type of nonmechanical failure are decrease in insulation value or increase in susceptibility to mildew.

Group 4. Initial Transudation

Method 4.1 The specimen is subjected to a definite head of water until droplets show underneath. The time required for the droplets to appear is taken as the measure of water resistance.

Method 4.2 A dry indicator, usually a powdered water-soluble dye mixed with a much larger amount of powdered sugar, is sprinkled on the upper surface of the specimen and the specimen is then floated on water. The time for water to come through and develop the color is a measure of the water resistance (*1*). A fluorescent dye is sometimes mixed with the powdered sugar (*3*). Or, a fluorescent dye may be used alone (*7*). Powdered potassium permanganate is another dry indicator sometimes used (*6*).

Method 4.3 A cup, made by suitably folding the material to be tested, is partially filled with water, placed on a ground-glass surface, and lifted periodically. Moisture that penetrates through collects in the fine surface fissures of the ground glass and appears as a dark, fugitive patch when the container is lifted.

Method 4.4 The specimen is floated on a dilute solution of ammonium thiocyanate, and some ferric chloride solution is applied to the upper surface. When the solutions meet a red color appears, and the elapsed time is taken as a measure of water resistance. This is not strictly a water-resistance test as tentatively defined above, but is included because it is sometimes used in long-period tests of water-resistant materials.

Method 4.5 The specimen serves as a septum in an electrolytic cell that contains water as the electrolyte. The time of penetration of water through the specimen is presumed to be the time required for the electric current to build up to a certain point. This method is used primarily as a sizing test but is included because the penetrant is water.

Group 5. Discharge Rate

Method 5.1 Water in a permeability cell, in contact with the specimen sealed to the cell, penetrates through the specimen and evaporates into air having a certain temperature and humidity. The rate of loss in weight of the cell is an inverse measure of the water resistance of the specimen.

UTILITY OF THE VARIOUS METHODS

Twenty-five or thirty years ago method 4.1 was in common use. A head of perhaps a foot or two of water was commonly used. Before the day of the widespread use of papers laminated or saturated with asphalt and other waterproofing media, heavy rosin-sized wrapping and bag papers were represented as "waterproof" because they would withstand this test indefinitely. More sensitive methods developed later showed that such papers allowed water to pass through rather freely, yet slowly enough so that the water would evaporate as fast as it reached the free surface. Thus liquid water could never appear on the surface exposed to the air.

The several types of water-resistance tests are largely a reflection of the fact that they serve different purposes. For moisture barriers, methods of groups 4 and 5 are most suitable. Methods of group 3 are used to determine the effect of wetting upon properties necessary to uses other than merely preventing moisture transmission. The data obtained from methods of groups 1 and 2 are not often of direct significance, but rather they are used as indirect means of guessing at other properties, perhaps more difficult to measure directly. A dubious choice of method is sometimes indicated. Wallboards, for example, are often given

an absorption or a penetration test when the change in dimensions, strength, or insulation value as a result of wetting would usually be more to the point.

All of the five types of water-resistance tests are useful in their own way, and all of the methods have limitations on their usefulness. Transudation tests seem generally to have been the most popular type of water-resistance test, and when moisture barriers are considered they are of course the logical type. What is usually desired is to know how well the material in question will keep moisture in or out when water is in contact with it. The methods of group 4 have been largely used in the effort to answer this question satisfactorily, and method 4.2, the dry-indicator technique, is probably used more than any other at the present time.

Another very reasonable and fairly simple transudation test that surprisingly has not been used very much is method 5.1 although a similar technique is very popular for testing water-vapor permeability. Perhaps the reason for its neglect is that suitable lightweight permeability cells for making the test have not been readily available until recently. Since one measures directly the periodic loss in weight from a cell containing water in contact with the specimen, and since the water can escape only by going through the specimen, the test answers directly the question: what amount of water will get through a barrier in a given time? The method has the further advantage that the weighings can be made at any convenient time. There are no midnight end points.

A convenient cell now available has been described in connection with water-vapor permeability techniques (*2*). It is a shallow dish with a grooved edge to aid in making a good seal with wax. It exposes 50 square centimeters of the specimen to the air, and yet is small enough to be weighed on the ordinary balance pan. The seal is made in the upright position. The water can be put in before the seal is made, or a small hole can be made in the bottom of the cell through which the water can be added later. The hole is then covered with a small aluminum disk and sealed with wax. The test is made with the cell upside down with the inside surface of the specimen in contact with water and the outside surface in contact with the standard atmosphere (50% humidity, 23°C.) for paper testing. The loss in weight with time gives the rate of passage of water through the barrier.

SOME CRITICISMS OF THE DRY-INDICATOR METHOD

The remainder of the discussion will be devoted to the dry-indicator method in view of a mixed feeling of popularity and distrust that seems to have developed with its expanding use.

The dry-indicator method was developed originally as a sizing test for short-period testing, but because of its sensitivity, simplicity, and convenience it has been taken over for the long-period testing of moisture barriers also. Its versatility is unusual. From its original application as a sizing test for papers of the writing class, the method has been extended to the evaluation of wrappings, bags, food wraps, sheathing paper, caselining, multiple-ply products of various sorts, boards, and even insulating boards. Although the wisdom of some of these applications may be questioned, the method is perhaps the most widely used water-resistance test employed today. It has been made a TAPPI Standard and also serves as an ASTM method.

Despite the general popularity of the method, however, it has been criticized more or less severely in some quarters. One group of workers (*7, 10*) has criticized the method as being fundamentally defective, while another report indicts it with having a very large "blind spot" (*9*). Some criticisms that have been made are not altogether without basis, while others seem to have arisen partly out of a misunderstanding of what the test might be expected to do and partly out of differences in the definitions of water resistance.

The most familiar criticism is that the end point is too indefinite. There is nothing comparable to a pointer passing a fixed point on a scale or an instantaneous change to clearly define the end of the test. The color appears at first dimly and uncertainly, gradually developing to a dark violet. The end point aimed at is somewhere in between when the rate of change is judged to be most rapid. This kind of an end point is unquestionably indefinite, but the consequent hazard to the test is more apparent than real. The resulting uncertainty is probably of the order of 10% for a given observer and somewhat more for different observers. An uncertainty of 10% is adequate for most purposes. Many of the common tests of paper have comparable uncertainty. For example, some of the TAPPI Standards give as estimates of reproducibility and precision: bursting strength 5%, tensile strength 5%, tearing resistance 7%, air resistance 5 to 10%, water absorptiveness 10%. For some tests, such as folding endurance and turpentine penetration (grease resistance), an estimate is not even hazarded.

Another annoying aspect of the end point, when the method is used for long-period tests, is the not infrequent occurrence of the end point at a most inconvenient hour. It may occur during the night and the test is lost. Reichel has been working at the National Bureau of Standards on this aspect of the problem and has developed a device for obtaining a photographic record of the test specimen at intervals of a few minutes. He obtains a continuous record of the development of the end point even while no observer is present.

The criticism with the most serious implication avers that the method does not measure liquid water resistance at all but rather measures the resistance to transport of water vapor. This contention seems to be based on the following propositions (*7, 10*).

(a) In a water-resistance test, liquid water must appear and be identified as such on the indicator side of the specimen.

(b) The end point will appear in time if the paper is not wetted but is merely exposed to saturated water vapor.

(c) In the testing of some insulating boards by the dry-indicator method, the end point may develop before the board has become saturated to any considerable depth with liquid.

The conflict between this viewpoint and the conventional one appears to hinge on definition. What does one ordinarily mean by water resistance? In examining this question one must bear in mind that the passage of moisture through paper is not a simple phenomenon. It usually involves one or more changes in phase. Liquid entering and passing through paper often emerges as vapor. Water vapor entering paper usually is adsorbed and may migrate chiefly in the condensed phase, only to emerge again as vapor.

In the case of barrier materials the implications are fairly clear. If water resistance is to be measured, one wets a face of the sheet with water and finds how rapidly the water gets through and manifests itself in some appropriate manner at the other face. One is not concerned with how it gets through, what phase is found within the sheet, nor what phase emerges. Likewise, if water-vapor permeability is to be determined, one subjects a face to water vapor of known degree of saturation, while maintaining the opposite face at a definite, lower vapor pressure, and measures the rate of escape of water from the low-pressure side without any thought of how many or what kind of phase changes may occur in the process. In both cases the criterion for the nature of the test is simply the entering phase. Although this criterion is usually taken for granted in testing the permeability of various materials to fluids, it is sometimes questioned, as indicated in the criticisms cited above.

What are the alternatives? The eight combinations of the two phases in the three locations (at the entering face, "entering," within the structure of the sheet, "migrating," and after leaving the sheet, "emerging") are shown in the table below.

Table I. Eight Possible Combinations of Moisture Phases at Each Surface and Within the Specimen in a Moisture-Transmission Test

Entering phase	*Migrating phase*	*Emerging phase*
Liquid	Liquid	Liquid
Liquid	Liquid	Vapor
Liquid	Vapor	Liquid
Liquid	Vapor	Vapor
Vapor	Liquid	Liquid
Vapor	Liquid	Vapor
Vapor	Vapor	Liquid
Vapor	Vapor	Vapor

In fact, the actual situation is even more complex since the two phases can co-exist, especially within the sheet.

If one insists that the same phase must appear in all three locations to properly characterize the test, only the first and last cases in the above table are applicable. What of the other six?

In order to put all of these cases in two categories one must select one key location for defining the test. Conventionally the entering phase is chosen. What are the objections to the choice of the other two locations?

Can we logically distinguish between water resistance and water-vapor resistance on the basis of the phase in which water migrates through the sheet? Both the attenuated phase and the condensed phase are usually present with the dominant phase in most papers and films having properties much nearer to those of a liquid than of a vapor. Furthermore, we can not know in each particular case what phase or phases are present in the structure nor in what proportion. In a water-resistance test we can not require that the structure be completely saturated with liquid. There is no logical necessity for liquid water to fill the larger interstitial spaces (if these do not wet readily) in order for water to migrate through the fiber canals and fine structure.

Still less fitting as a criterion for the nature of the test is the emerging phase. It will normally be vapor in a flotation test since there is no hydrostatic pressure. Even when the technique provides a substantial hydrostatic pressure, as in method 4.1, it often happens that the water evaporates as fast as it reaches the low-pressure side and can never become manifest as liquid although the rate of transmission may be fairly high. If conditions are arranged so that an end point is not obtained until the liquid state or a saturated condition at the exit surface is reached, sensitivity is thereby sacrificed. It is obvious that if, in a flotation test, we require the indicator side to become as wet as the surface of origin of the water, there would be no driving pressure towards the end of the test.

In the case of protective materials, moisture barriers, and the like, it makes no practical difference which phase shows up on the forbidden side. Vapor or liquid, *in the same amount*, will equally damage water-sensitive merchandise since vapor will be condensed by adsorption on a surface such as polished steel or within hygroscopic substances such as foodstuffs.

It is known that the rate at which moisture enters the sheet may be influenced greatly by the phase that enters. A waxed paper, for example, may perform fairly well if exposed to high humidities but becomes a poor barrier against liquid water in contact with it. In a test we always know what the entering phase is. The conventional manner of naming the test according to the entering phase is the most logical way.

If the entering phase in the test is liquid, water resistance is tested; if the entering phase is water vapor, water-vapor resistance is tested.

The dry-indicator technique allows us to make a water-vapor resistance test (although a poor one) by admitting saturated water vapor instead of wetting the surface with liquid water. The test time is much increased, but the indicator will eventually begin to show color. We find that the color will begin to develop when the relative humidity on the indicator side has risen to about 85%. The fluorescent indicators, or any other feasible substitute, will also develop color in time when used in the same way although some of these may require a higher humidity on the exit side and consequently a longer time.

There are some data of conventional gravimetric water-vapor permeability tests and dry-indicator tests made on the same papers. These data refute the contention that the dry-indicator test is a test for water-vapor permeability inasmuch as the correlation between the two tests is poor.

One published report (*8*) contains data for the two tests on nine types of materials, including waxed glassine, pliofilm, cellophane, ethyl cellulose, and several laminated materials. These data show that

some materials of comparable water-vapor permeability differed greatly in water resistance as measured by the dry indicator test, the difference in one case being several hundredfold.

Another report (*5*) on 25 or 30 asphalt-laminated caselining papers (in which some correlation might not be surprising because the papers are all of the same general type) also shows rather poor correlation between the two tests.

One of the most important reports (*7*) bearing on this subject proposed an improved method and apparatus, involving the use of a fluorescent dye, chosen because the end point is not sensitive to water vapor that diffuses ahead of the water as it penetrates through the test specimen. Nearly a hundred papers of various kinds and weights were used in comparing the results by this method with those obtained by the sugar-dye technique. The data do not support the allegation that the correlation is poor and that the sugar-dye technique is basically defective.

If one compares or plots the data of one test against the other, one finds as good a correlation as the paper technologist is accustomed to finding in many comparisons which are regarded as satisfactory. If one examines the ability of the two tests to arrange the papers in the same order of water resistance as measured by the two methods, one finds fairly good correlation. This can be done to good advantage by means of the Kendall correlation coefficient (*4*).

On a scale of zero for no correlation and unity for perfect correlation, a Kendall correlation coefficient of 0.7 to 0.8 is obtained for the data in the three pertinent tables given in the report, which is better than the correlation with two other well-known methods also included in the study.

One table gives data for two versions of the fluorescent-dye technique, a visual method, and a photoelectric method, in comparison with the sugar-dye (TAPPI) technique. The correlation coefficient (Kendall) between the two versions of the advocated technique (*7*) is 0.8; that between the advocated technique (fluorescent-dye) (*7*) and the technique under criticism (TAPPI dry-indicator) is also 0.8.

There are some incidental limitations on the dry-indicator method which are not so well known. Once in a great while one encounters a material with which the method will not work at all. One paper met with in this category was heavily infused with a soluble salt to make it fire-resistant. The solution that formed as the water penetrated through the test specimen acted upon the indicator in some way to prevent the color from developing.

Some materials have a pronounced two-sided behavior toward the dry indicator. This is perhaps most apparent in laminated moisture barriers. Suppose one is testing a duplex asphalt-laminated paper having a thin paper on one side that is well saturated with asphalt, and a thick, bulky material on the other side into which the asphalt has not penetrated very far. If one puts the indicator on the thick, bulky surface one will usually get a longer test time than if the specimen were reversed. The reason is rather obvious. The indicator requires a certain amount of moisture to make the color develop. A part of the moisture that comes through is taken up by the bulky surface sheet so that a larger total amount is required as compared with that required when the sheet is reversed and the indicator alone has to be satisfied.

One reason that different technicians sometimes obtain results that do not agree satisfactorily is that different batches of dry indicator, made according to the approved specification, may behave quite differently. This problem has been studied to some extent, and the reason appears to be that batches of methyl violet (the dye specified in the standard method) obtained from different sources often differ considerably in solubility, rate of solution, sensitiveness to small amounts of moisture, and color characteristics.

Another type of criticism discounts the dry-indicator method because it is blind to certain physical changes that go on after the end point is reached. This criticism is based particularly on its poor correlation with the ink-penetration test, and a wet-strength method is suggested instead (*9*). Criticism of this type illustrates a confusion which is not uncommon and also directs attention to the fact that "sizing" performs other functions in addition to that of imparting water resistance to paper. We cannot expect tests designed for different purposes to be interchangeable. Ink penetration involves selective adsorption and filtering out of some of the ingredients of the ink with consequent blocking and slowing of the process of permeation, and may be very different from the penetration of water alone. Wet strength and the rate of penetration of water or an aqueous solution may be related phenomena, but one is not the measure of the other.

There is room enough and need enough for all of the five types of water-resistance tests that have been discussed. The dry-indicator method represents but one of these types. Its proper use is in determining how rapidly moisture will get through a material if water is in contact with one side. With the exercise of caution one can often deduce from the results useful information about other related properties more difficult to evaluate. In its legitimate field the dry-indicator method is very valuable as a simple, sensitive, rapid test for water resistance.

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Reseeding B.O.D. Bottles

A Means of Detecting Toxic Interference in the B.O.D. Test

GEORGE C. BORDEN, JR. and IRENE WOODCOCK

The effluent from paper mills may possess toxic properties. The B.O.D. test on such effluents will be distorted unless toxicity is recognized and corrected. The recognition of toxicity may be difficult for the average B.O.D. analyst by the means now usually employed. Data are presented showing that the reseeding of B.O.D. bottles will clearly point out toxic interference in the test. A method for reseeding is given. The method employs a system of duplicate bottles. Reseeding is demonstrated as it proceeded under two schedules. Safeguards to the equilibrium of the test are provided for in the technique.

PAPER MILL effluents may contain substances hostile to the normal rate of biological oxidation. Mercury compounds, pentachlorophenates, some dyes, chlorine residuals, extreme pH values, or experimental additives such as oxidizing agents, when present in the effluent, may either kill or inhibit biological organisms (*1*). Such effluents are then toxic or inhibitory depending upon the nature and concentration of the irritant. As a consequence, the biological oxidation process ceases or lags.

In that event, Gehm (*2*) points out, the B.O.D. test does not fulfill its purpose. It does not give an accurate measure of the amount of oxygen necessary to stabilize the organic content of the effluent. Phelps (*3*) makes it abundantly clear why this is true. The B.O.D. test, he teaches, depends upon biologic organisms. To properly function, such instruments require a medium favoring life processes, which is to say, that metabolism must proceed normally.

But how can abnormal metabolism, as manifested by a lowered oxygen demand, be detected as a factor in B.O.D. determination? The question regularly confronts the B.O.D. analyst who works with paper mill effluents. Authorities like Rudolfs and Axe (*4*) have alerted the analyst to the need of facing the question by showing that many B.O.D. variables are at work in the paper mill.

DETECTION METHODS

In the B.O.D. laboratories of specialists, several more or less satisfactory methods are at hand for detecting toxicity. Two of these methods can be readily adapted to the needs of B.O.D. analysts in the paper laboratory. One is the plating method, the other is the comparative dilution method.

Plating Method

The plating out method is based on techniques directly derived from standard bacteriological procedures. Measured amounts of waste are plated in agar and incubated. The colonies resulting are examined morphologically for size, shape, color, etc. Low counts or mutated development indicate toxicity. The following short data form expresses a typical analyzation by this method.

Bacteriological Examination of Effluent. Predominate morphological and cultural characteristics of colonies grown on nutrient agar for 48 hours at 98.6°F.

Characteristic	*Untreated effluent, 1 ml.*	*Treated effluent, 1 ml.*
Count	300	190
Color	Deep yellow	Pale yellow-white
Luster	Bright, glistening	Dull
Rate of growth	Rapid	Slower
Form	Round	Round or irregular
Surface	Smooth	Smooth to pitted to curled
Optical	Translucent	Opaque

There are weaknesses in the plating out method which the B.O.D. analyst must recognize. First, the method is weak because it obtains mainly morphological data. Such data are less necessary to the proper evaluation of B.O.D. determinations than are data obtained from the physiologic and metabolic behavior of test organ-

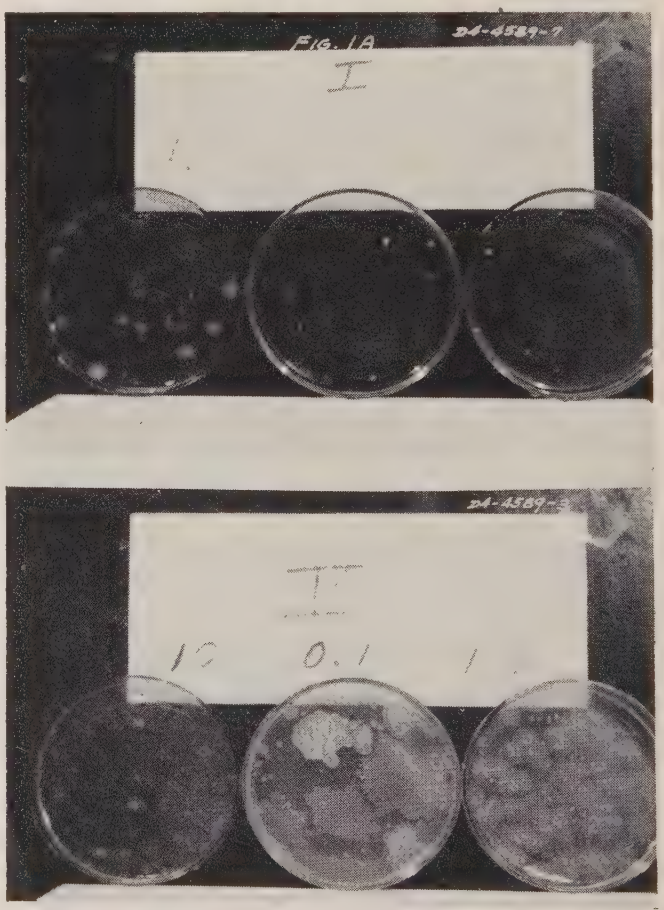

Fig. 1. I Colony development in plain waste; V Colony development in treated waste

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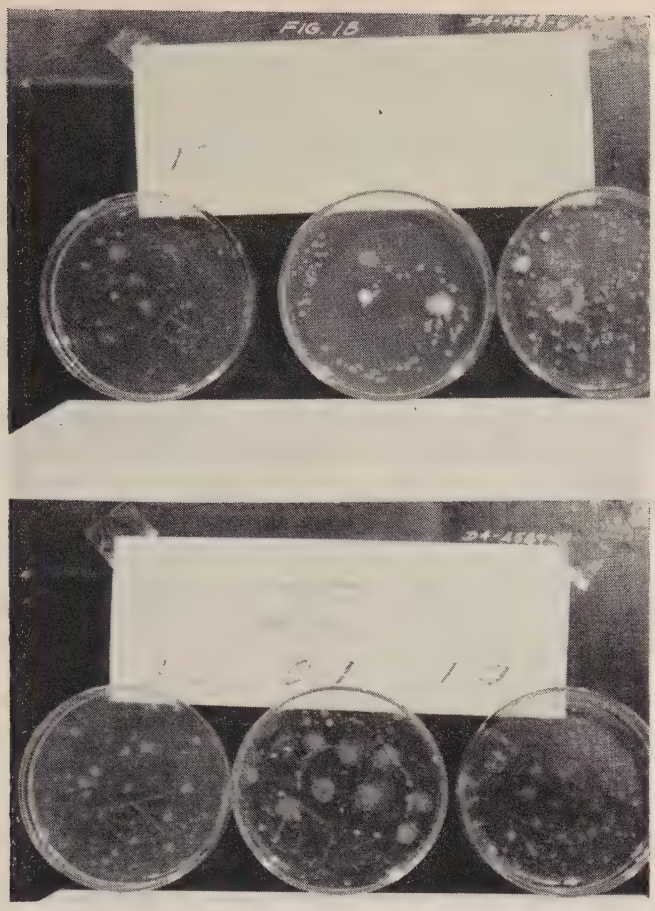

Fig. 2. II Colony development in plain waste; VI Colony development in treated waste

isms functioning in the test media. Often, by removing organisms from a stringent effluent and incubating them in an optimum agar media, a typical development is induced. Secondly, the method is weak because it cannot be controlled. Experience has shown that plates of living organisms may vary even when obtained under seemingly identical conditions. Without a specific control the method has little of value for the average laboratory. Finally the method is weak because in critical tests it may be indecisive. Two such instances are illustrated in Figs. 1 and 2.

Figure 1 pictures plain and treated samples of identical waste in three plate dilutions. Roman numeral I shows the colony development from straight mill effluent. Roman numeral V shows the colony development from the same waste to which had been added a small dosage of an experimental agent designed to lower the B.O.D. of the waste. It was necessary to determine the toxic properties of the treatment. An examination of the plates will show how questionable the results of plating out were for this determination. Between treated and untreated waste there was nothing in numbers of colonies, size, shape, etc., to make the plating out technique, in itself, determinate of toxicity.

Figure 2 is another case of much the same nature. Roman numeral II is straight mill effluent. Roman numeral VI is treated mill effluent. As in Fig. 1, it is evident that when plates such as these develop, experience beyond that of the usual B.O.D. analyst is required for a proper interpretation of results.

Dilution Method

The comparative dilution method is the second means commonly favored in the B.O.D. laboratory for revealing the interference of toxicants. To employ this method, several dilutions of waste are set up. If the B.O.D. in the higher dilutions is considerably higher than it is in the lower dilutions, toxicity is recognized. For the higher the dilution of waste, the lower is the concentration of any toxicant contained. The lower the concentration of toxicant, the more normal the oxygen consumption of the test organisms is presumed to be.

Dilution, %	*Untreated waste B.O.D., p.p.m.*	*Chemically treated waste B.O.D., p.p.m.*
	Example I	
10	65	30
4	60	20
2	80	15
1	90	Not titratable
	Example II	
10	28	7
4	37.5	12.5
2	35	Not titratable
1	50	Not titratable
	Example III	
10	27	17
4	27.5	15
2	25	Not titratable
1	30	Not titratable
	Example IV	
10	61	17
4	62.5	20
2	75	45
1	110	30

Experts in the field such as Heukelekian (*5*) and Ruchhoft (*6*) have set forth the advantages and limitations of the dilution method very clearly. An examination of their research is mandatory for all who would work intelligently with the toxicity problem in the B.O.D. test. On paper mill waste, the laboratory now reporting has, in the course of making several hundred B.O.D. determinations during the past year, found the method generally reliable. But as with the plating out method, instances were also encountered where certain agents did not produce the expected picture of toxicity in the higher dilutions. Such agents had reduced the B.O.D. by roughly 50% and so were suspect of toxicity. The above table shows that the dilution method left the question of toxicity open in some instances.

RESEEDING

Having encountered several instances where neither plating or dilution was satisfactorily determinant of toxicity, it was decided to employ an additional technique for the purpose. To that end, a reseeding operation was tried. In the authors' laboratory the method has been valuable, especially in making experimental as well as applied determinations. Experience with the method may show how some steps in the technique can be safely modified. Indeed, the authors know now of another industrial laboratory, who, while working with them, obtained good results with a modified technique. But until more data are obtainable from other paper laboratories it would seem wise to follow

the procedure outlined. That procedure was set up in such a way as to safeguard the equilibrium of the B.O.D. test, a vital precaution when handling biologic instruments.

Reseeding Schedules

Briefly, reseeding simply adds new seed to bottles of identical waste during the time of incubation. The schedules for such additions of seed are diagrammed in Fig. 3.

Principles

The reseeding concept was founded upon well-established principles. Before discussing the technique which instrumented the concept a brief review of those principles is made.

It is known that bacteria are either instantly destroyed by a toxicant or they are gradually weakened to the zone of half life or to the point of extermination. The degree of reaction depends upon the concentration and the nature of the toxicant. If concentration of toxicant is low, bacterial deterioration is, in most cases, gradual. Time, in such a situation, serves to accelerate germicidal action; as the bacterial population becomes gradually inactivated, the concentration of the toxicant relatively increases. However, an additional factor also operates in the battle between concentrations of toxicant and concentrations of challenge organisms. That factor is the exhaustion stage of the toxicant. Such exhaustion develops as more and more of the toxicant unites with the bacterial organic matter. By so uniting the toxicant concentration is increasingly transformed into insoluble, inert compounds. In such a state, toxicants are ineffective against cell life. The toxicant is then exhausted.

One further factor in the complex operations of toxicant, bacterial warfare must be considered.

Organisms are not always destroyed or deteriorated by a toxicant. Some organisms are able to build up through generations, a resistance to irritants. They then are considered able to adapt or acclimatize themselves to the irritation of their environment. Such an ability is often correlated with the age of the organisms.

Purposes of Reseeeding

Against that background of fact, reseeding, as experimented with, attempted to accomplish several things. The primary objectives were: (a) to provide a quantity of seed able to survive beyond the point of toxic exhaustion (schedule A), and (b) to provide mature seed acclimatized to a toxic environment (schedule B).

Additionally reseeding sought data significant to the B.O.D. reaction by: (a) showing the rate at which known additions of seed accelerate the reaction, (b) pointing out the time or area of toxic exhaustion, and (c) making possible a toxicity rating expressable in the same mathematical terms as the B.O.D. reaction and correlated to it.

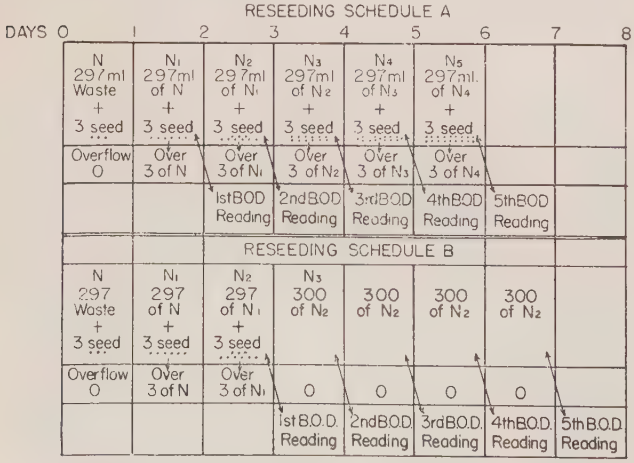
RESEEDING SCHEDULE A
DAYS 0 1 2 3 4 5 6 7 8
N 297 ml Waste + 3 seed
N1 297 ml of N + 3 seed
N2 297 ml of N1 + 3 seed
N3 297 ml of N2 + 3 seed
N4 297 ml of N3 + 3 seed
N5 297 ml. of N4 + 3 seed
Overflow 0
Over 3 of N
Over 3 of N1
Over 3 of N2
Over 3 of N3
Over 3 of N4
1st BOD Reading
2nd BOD Reading
3rd BOD Reading
4th BOD Reading
5th BOD Reading
RESEEDING SCHEDULE B
N 297 Waste + 3 seed
N1 297 of N + 3 seed
N2 297 of N1 + 3 seed
N3 300 of N2
300 of N2
300 of N2
300 of N2
Overflow 0
Over 3 of N
Over 3 of N1
0
0
0
0
1st B.O.D. Reading
2nd B.O.D. Reading
3rd B.O.D. Reading
4th B.O.D. Reading
5th B.O.D. Reading

Fig. 3. Diagrammatic pattern of reseeding

TECHNIQUE AND APPARATUS

General

Standard B.O.D. equipment and standard techniques were employed for all determinations. Standard Methods (7), ninth edition, was followed. Certain additions and emphases were necessary for reseeding as are enumerated.

Glassware

"Clean" glassware was used for all tests. It was made so by these steps, none of which should be slighted if reproducible results are to be attained. The B.O.D. bottles were: (a) washed clean in soap suds, (b) rinsed thoroughly with tap water, (c) rinsed in chromic acid cleaning solution, (d) rinsed with tap water, (e) rinsed with distilled water, and (f) autoclaved.

Apparatus

Beyond the customary apparatus and equipment for the B.O.D. test, these pieces were used additionally:

(a) A B-D Leur syringe of 30 ml. capacity graduated at 1 ml. intervals.

(b) A Leur slip B-D Yale needle, gage 19, length $2^1/_2$ inches.

(c) A wooden box $25^1/_2$ by $19^1/_2$ by 16, hermetically taped, with arm openings, rubber sleeves attached. The box had a plate glass top permitting a full view of the box interior.

The Seed

The seed used was flora and fauna combined from two sources. It consisted of 1 part standard sewage and 2 parts Musconetcong River water. Three milliliters of this combined seed were introduced into the B.O.D. bottle at the time of original seeding and subsequently at the time of each reseeding.

This composition of seed was dictated by the reproducible results obtained with it. Straight sewage at the rate of 1 ml. per liter, on some effluents, lagged. Straight river water, at the rate of 33.3 ml. per liter, disproportionately accelerated the velocity of the B.O.D. reaction when applied to the same effluents. This was particularly true during periods of low river volume and correspondingly high bacterial concentration.

By combining sewage and river water, a consistent pattern of results was achieved. The following data illustrate the effect of the three floras applied, comparatively, to the same dilutions of identical waste.

Samples	B.O.D. with sewage	B.O.D. with river water	B.O.D. with combined flora
1	60	185	80
2	40	140	50
3	80	190	98
4	80	235	87.5
5	24	98	55
6	60	125	72
7	30	135	85

The Effluents

Mill effluents from a wide variety of furnishes were reseeded. Among such were kraft, rag, sisal, jute, sulphite, deinked waste, wool tare, and burlap. Tests were made on wash waters, bleach washes, cook washes, combined washes, machine white waters, oliver washes, and main sewer discharges.

The Schedule

When reseeding, the B.O.D. test was set up in the following way:

1. The effluent to be tested was divided into two parts, after first dispersing the organic matter by gentle blowing through a 25 ml. open end pipet.

2. One part of the waste was treated according to plan; the other part remained untreated as the control.

3. The treated and control waste was set up in as many dilutions as necessary according to Standard Methods.

4. Three bottles were set up on both portions of waste for each of the days of incubation. Thus for each dilution the set up was:

Days	Bottles of plain waste			Bottles of treated waste		
1	A	B	C	A	B	C
2	A	B	C	A	B	C
3	A	B	C	A	B	C
4	A	B	C	A	B	C
5	A	B	C	A	B	C
10	A	B	C	A	B	C
20	A	B	C	A	B	C

The A bottles were all reseeded at the end of 24 hours incubation. At the end of 48 hours one A bottle was read out. All the remaining A's were again reseeded. The process was repeated each day during incubation.

The B bottles were all reseeded at the end of 24 hours. None were read out. Again after 48 hours all the B bottles were reseeded. Thereafter no reseeding of B bottles was done. The reading out of the B bottles began after 72 hours incubation and continued at the rate of one per day throughout the test period.

The C bottles were not reseeded. They were the controls. The reading out of the series proceeded at the rate of one per day beginning at the end of 24 hours incubation.

As is shown by the reseeding diagram Fig. 3, the reseeding was timed to perform a dual purpose. Under schedule A, a measured quantity of new seed was added to each test bottle 24 hours before determining the B.O.D. Such a schedule accomplished this:

(a) It supplied the waste quantitatively with a normally vigorous, challenging population every 24 hours throughout the test period.

(b) It introduced quantitative reinforcement at measured intervals so as to have the vital seed immediately available once the toxicant had exhausted itself.

(c) It provided quantities of vigorous seed able to pick up the lag occasioned by an agent that was either slightly depressant or severely toxic.

Under schedule B a measured amount of new seed was added to each test bottle at the end of 24 hours, and again at the end of 48 hours. Thereafter, no new seed was added during the incubation period. That schedule accomplished this:

(1) It provided the waste with two quotients of new seed supplied during the outset of the incubation. The quotients were spaced sufficiently far apart to reinforce the original seed should that have been either instantly knocked out or gradually devitalized.

(2) It accomplished this with a more conservative regard for the normal ratio of food concentration to bacterial population than did Schedule A.

(3) It avoided the danger of overpopulating the waste should the toxicant be mild.

(4) It allowed time for generations of acclimatized organisms to develop free of competition from unadjusted organisms.

Method

According to the schedule being followed (A or B), the bottles to be reseeded were transferred from the incubator to the reseeding box. The temperature of the box was held constant with the incubator throughout the test period. Just before entering the box, the water seal was tipped off.

The oxygen content of the reseeding box was exhausted. This was checked by a technique often employed in bacteriology for the study of obligate anaerobic bacteria. That technique for checking the absence of oxygen makes use of the methylene blue indicator functioning from its blue, oxidized state to its white, reduced, leuco state. The methylene blue indicator is made from three stock solutions which are:

1. 6.0 ml. $N/10$ NaOH diluted to 100 ml. with distilled water.

2. 3.0 ml. 0.5% aqueous methylene blue diluted to 100 ml. with distilled water.

3. 6.0 grams of glucose in 100 ml. distilled water to which has been added a small crystal of thymol.

Each time an indicator solution was required equal parts of the three solutions were mixed in a test tube and boiled in a cup of water until the color disappeared. In that reduced or leuco state the tube was placed in the deoxygenated box. If the blue color returned to the indicator tube, leaks were checked. If the tube remained colorless in its reduced state and did not return to the blue or oxidized state, reseeding proceeded. A tube of soda lime was maintained in the box to absorb excess CO_2.

The bottles in the box were unstoppered with gentle action. The stopper so removed was held between the second and third fingers of the left hand so that contamination of it did not occur. By means of a syringe (sterile) and a flamed needle measured amounts of seed were introduced into the lower levels of the bottle contents. The needle in thus penetrating the surface layer of the test bottle opened a fine avenue

into the deeper layers of the bottle. No measureable amount of oxygen was introduced by such an opening, however, inasmuch as little oxygen was free in the environment to follow the opening.

Before introducing the needle into the bottle, an important step was taken. After the new seed had been pulled up into the syringe barrel, the plunger of the syringe was pushed down to expel the air contained. As soon as pushing upon the plunger delivered liquid it was known that the air had been expelled.

It will be borne in mind that the reseeding was accomplished by the arms and hands working through sleeves in a box whose interior was made visible by a plate glass top.

As the new seed was deposited at the bottom of the bottle, an equal amount of the previous contents of the bottle was made to rise and, upon restoppering, became the water seal.

Summary of Essentials

The bare essentials of reseeding are these:

1. Allow no organic matter such as dust, bits of blotting paper, or lint to fall into the open bottles.
2. Allow no air bubbles to be trapped if introduced inadvertently either by syringing, or restoppering the bottle.
3. Maintain the seed at incubating temperature.
4. Use the same flora and fauna throughout the test.
5. Be exact in delivering the new seed.
6. Maintain controls for each schedule of reseeding.

RESULTS

The data of reseeding B.O.D. tests were collected in a data form, the pertinent points of which are enumerated in the following typical example:

Reseeding Data Table—Treatment Y

Days	A *B.O.D. plain Quantitative reseed*	A_1 *B.O.D. treat Quantitative reseed*	B *B.O.D. plain cumulative reseed*	B_1 *B.O.D. treat cumulative reseed*	C *B.O.D. plain control*	C_1 *B.O.D. treat control*
1	..	..	..	..	22	10
2	40	20	..	..	40	15
3	63	40	69	50	59	25
4	70	48	75	65	65	29
5	75	62	80	75	70	33
6	84	72	89	83	..	..
7	..	..	110	105	..	..

An examination of the typical reseeding data table shows that in addition to the parts per million B.O.D. obtained by Standard Methods, column C, other pertinent determinations are possible. Letters are used to identify data columns. The additional determinations possible from the data are:

I. *The effect of quantitative and cumulative reseeding on the velocity of the B.O.D. reaction in plain waste.* (These data may contribute to the study of the vital relationship between seed quantity and quality and the B.O.D. results.)

A-C Difference between B.O.D. of plain waste reseeded quantitatively (schedule A) and B.O.D. of plain waste.

B-C Difference between B.O.D. of plain waste reseeded cumulatively (schedule B) and B.O.D. of plain waste.

II. *The effect of quantitative and cumulative reseeding on the velocity of the B.O.D. reaction in treated waste.* (These data may throw additional light on the metabolism of organisms when irritated.)

A_1-C_1 The difference between the B.O.D. of treated waste reseeded quantitatively (schedule A) and the B.O.D. of treated waste.

B_1-C_1 Difference between B.O.D. of treated waste reseeded cumulatively (schedule B) and the B.O.D. of treated waste.

III. *The effect of reseeding on B.O.D. results.* (These data make possible the detection of a toxic factor in the test waste.)

C-C_1 The difference between the B.O.D. of plain waste and treated waste.

A-A_1 The difference between the B.O.D. of plain waste quantitatively reseeded (schedule A) and treated waste quantitatively reseeded (schedule A).

B-B_1 The difference between the B.O.D. of plain waste cumulatively reseeded (schedule B) and treated waste cumulatively reseeded (schedule B).

Interpretation of Data

Using the readings obtained at the 5-day level from the reseeding table of treatment Y, the results are expressable in mathematical terms as follows:

I

1. Reseeding plain waste under schedule A raised the B.O.D. about 7%.

75 p.p.m. — 70 p.p.m. = 5 p.p.m.

2. Reseeding plain waste under schedule B raised the B.O.D. about 14%.

80 p.p.m. — 70 p.p.m. = 10 p.p.m.

Thus, reseeding plain waste raised the B.O.D. an average of 10%.

II

1. Reseeding treated waste under schedule A_1 raised the B.O.D. about 88%.

62 p.p.m. — 33 p.p.m. = 29 p.p.m.

2. Reseeding treated waste under schedule B_1 raised the B.O.D. about 127%.

75 p.p.m. — 33 p.p.m. = 42 p.p.m.

Thus, reseeding treated waste raised the B.O.D. an average of 107%.

III

1. The treatment with no reseeding reduced the B.O.D. about 53%.

70 p.p.m. — 33 p.p.m. = 37 p.p.m.

2. The treatment with schedule A reseeding applied to both plain and treated waste reduced the B.O.D. about 17%.

75 p.p.m. — 62 p.p.m. = 13 p.p.m.

3. The treatment with schedule B reseeding applied to both plain and treated waste reduced the B.O.D. about 6%.

80 p.p.m. — 75 p.p.m. = 5 p.p.m.

Thus, the treatment with reseeding reduced the B.O.D. an average of 11.5% which is to say that the treatment exhausted of toxicity reduced the B.O.D. by 11.5% on the fifth day of incubation. At the end of 7 days incubation no appreciable B.O.D. reduction remained.

IV

1. The treatment was proved toxic. Therefore the B.O.D. reduction obtained by it was not valid.

Original B.O.D. treatment = 53% reduction
Reseeding = 0% B.O.D. reduction.

2. The fifth day quantitative toxicity value of treatment Y was:

A_1-C_1: C = 29: 70 p.p.m.

3. The fifth day cumulative toxicity value of treatment Y was:

B_1-C_1: C = 42: 70 p.p.m.

Thus, average toxicity value of treatment Y

35 p.p.m.: 70 p.p.m.
35/70 = $^1/_2$ = 50% toxicant influence on B.O.D.

B.O.D. reduction with treatment = about 50%. Reseeding toxicity rating of treatment = 50%. Therefore, treatment Y made no valid reduction in B.O.D.

Percentage Results

Data tables expressed in percentages offer a ready means for observing the effect of reseeding, as an examination of the following table shows.

Percentage Tables of Typical Results

Treatment	*Days of incubation*	*B.O.D. reduction of treated over plain waste, %*	*B.O.D. reduction of treated over plain waste, quantitative reseed, %*	*B.O.D. reduction of treated over plain waste, cumulative reseed, %*
M	1	60	..	..
	2	60	40	..
	3	50	10	0
	4	40	0	0
	5	45	0	0
	6	..	0	0
	7	..	..	0
N	1	90	..	..
	2	70	22	..
	3	60	25	25
	4	54	25	20
	5	50	10	8
	6	..	10	5
	7	..	..	0
O	1	40	..	..
	2	50	40	..
	3	40	40	40
	4	35	35	25
	5	30	20	20
	6	..	15	10
	7	..	..	5
P	1	75	..	..
	2	75	70	..
	3	40	40	40
	4	40	20	30
	5	40	10	35
	6	..	0	40
	7	..	..	40

Reseeding in Parts per Million

Other examples of the effect of reseeding expressed in parts per million also show how original B.O.D. reductions fail to hold up when the waste is exhausted of toxicant.

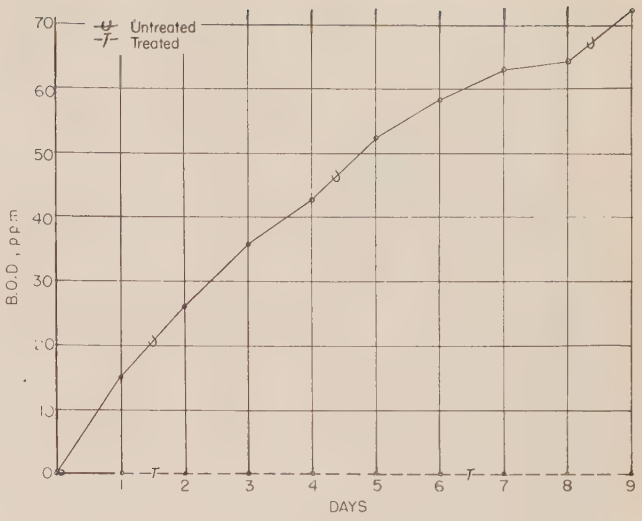

Fig. 4. Effect of a total toxicant-chemical A

B.O.D. Reductions Obtained per Part per Million for each Part per Million of treatment used

Test No.	*Reduction, 5th day* No reseed	A reseed	B reseed	*Reduction, 6th day* No reseed	A reseed	B reseed	*Reduction, 7th day* No reseed	A reseed	B reseed
1	2.5	2.0	0.4	..	0.2	0.3	..	..	0.0
2	0.6	0.3	0.3	..	0.3	0.0	..	..	0.0
3	1.5	1.1	1.1	..	0.9	0.9	..	..	0.4
4	2.0	1.7	0.2	..	1.3	0.2	..	..	0.1
5	0.6	0.9	0.6	..	0.4	0.2	..	..	0.0
6	2.2	2.0	1.4	..	1.0	1.2	..	..	0.6
7	2.6	2.5	2.4	..	2.2	2.2	..	..	2.1
8	2.5	1.0	0.2	..	0.1	0.0	..	..	0.0
9	2.9	2.7	2.4	..	0.9	2.5	..	..	0.2
10	2.4	1.0	1.0	..	0.9	0.3	..	..	0.0
11	0.5	0.3	0.3	..	0.3	0.0	..	..	0.0
12	1.8	1.0	0.9	..	0.4	0.4	..	..	0.1
13	4.8	0.0	0.0	..	...	...	..	..	...
14	3.1	0.4	2.0	..	0.0	1.5	..	..	1.3
15	2.5	1.9	0.2	..	0.2	0.2	..	..	0.0

Results

Graphs of several reseeding tests are given as being representative of the authors' work with the method. Each effluent had been treated experimentally for B.O.D. reduction by chemical agents. In all cases the dilution graphed was that which depleted nearest to 50%.

The introduction of chemical A into the waste produces a picture of total sterilization as shown in Fig. 4. B.O.D. results on the untreated waste, as read out daily for 9 days, form a near normal curve. In the waste treated by chemical A, however, no demand develops during the entire test period. The conclusion, clearly evident, is that chemical A has destroyed all the organisms present. None remain to use oxygen. Such a result is extreme and being extreme, toxicity is easily recognized.

Chemical B was tried on a waste of very low demand: 100% waste concentration depleted 45% in 5 days (Fig. 5).

The 100% concentration of waste naturally contained a full concentration of the treatment. The results show that either (a) chemical B has actually reduced the B.O.D. by over 70% or the treatment has inhibited normal metabolism.

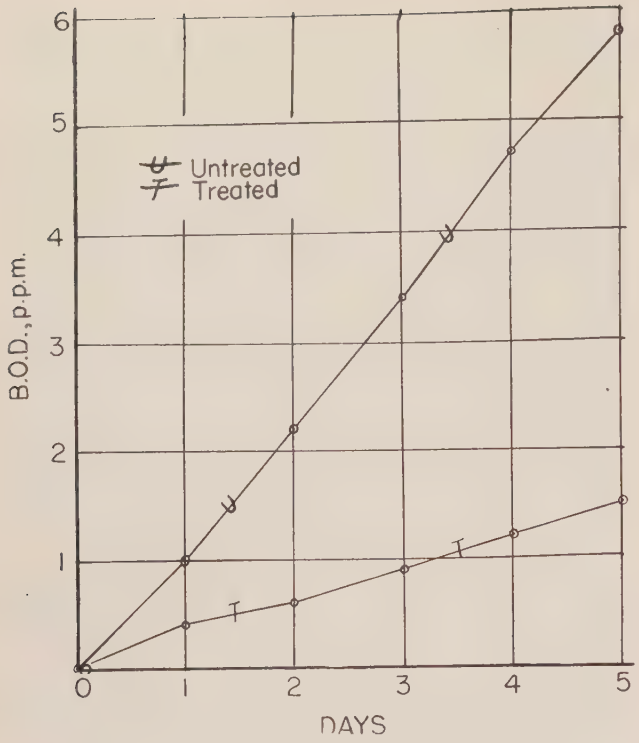

Fig. 5. Effect of lag chemical B in 100% waste

Figure 6 shows the same treatment as in Fig. 5 which was tested for toxicity by means of reseeding. The comparative percentage reductions clearly reveal that the treatment is bacteriostatic. At the 5-day level the reseeding results show:

Not reseeded—treatment reduces the B.O.D. about 70%.
Reseeded quantitatively—the reduction is about 18%.
Reseeded cumulatively—the reduction is about 9%.

No reduction remains at the conclusion of the test.

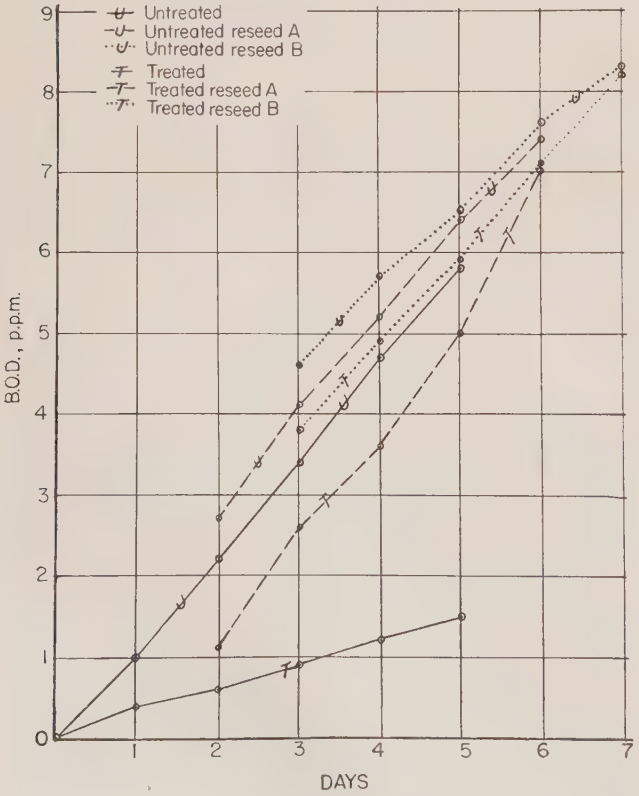

Fig. 6. Effect of reseeding chemical B in 100% waste

Toxic exhaustion apparently occurs between the second and third day.

In Fig. 7 chemical B is shown also in a waste of considerably higher B.O.D. value than in Fig. 6. A 5% dilution of that effluent depleted the nearest to 50% in 5 days. It will be noted that reseeded waste in the treated condition in the 5% dilution more closely aligns itself to the treated waste not reseeded than is the case in the 100% concentration of treatment. The reason for this closer alignment is to be found in the lowered toxicity of the waste in the lower concentration of treated waste. (Previous reference has been made to the dilution method of detecting toxicity.) In this instance reseeding by schedule A at 5 days does not reveal inhibitory action in the waste, but schedule B does clearly indicate that such is the case. At the 7-day level schedule B proves toxicity beyond doubt.

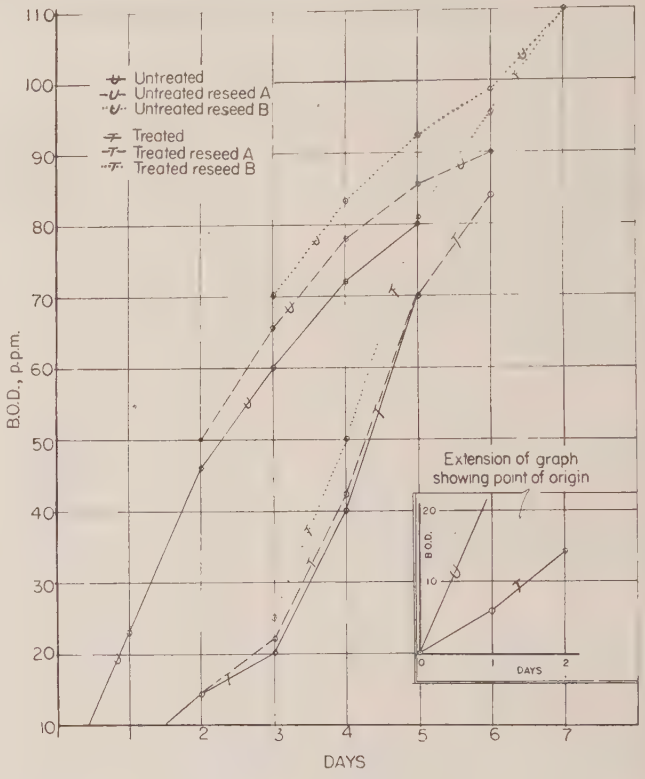

Fig. 7. Effect of reseeding chemical B in 5% waste

Chemical X was used on a waste of low B.O.D. value (Fig. 8.) During the first 24 hours a lag occurs in both the plain and treated samples. In the treated samples the lag persists for 48 hours. The reseeding on this test dropped the sewage component of the flora and hence consisted of 100% Musconetcong River water. The flora of that water causes an extreme acceleration in the reseeded samples as the graph shows. Toxicity is demonstrated as is also the influence of flora on the ultimate B.O.D. determination.

Chemical C treated a mill effluent of a value such that the 5% dilution was nearest the 50% depletion (Fig. 9). In that concentration the treatment was of doubtful toxicity.

At the end of 5 days the treated samples when not reseeded show a reduction of about 30% in B.O.D.

When reseeded by schedule A, the results on the fifth day also show a 30% reduction. The B reseeding on the fifth day also give about a 30% reduction. However, by the seventh day of B reseeding the gap has narrowed to a mere 6% and toxicity is shown even though present to a very slight degree.

The action supplied by chemical D is another illustration (Fig. 10) of how revealing reseeding can be in determining even slight toxicity. Here the curves between the plain effluent and the treated effluent closely correspond. At the end of 5 days a reduction in B.O.D. of about 12% is shown. But the reseeded samples close that small gap and prove the treatment inhibitory to normal metabolism.

The reseeding in Fig. 11 shows a result occasionally met. Here the reseeding depresses rather than accelerates B.O.D. values.

In such cases it would appear that the ratio between bacterial population and food concentration is materially altered by reseeding.

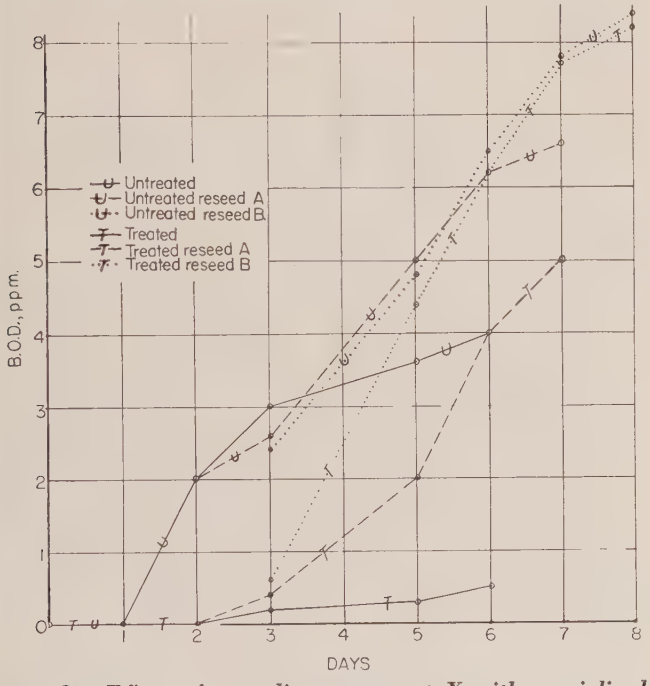

Fig. 8. Effect of reseeding treatment X with specialized seed

In that event, it is well to retest by: (a) setting up the test in lower dilution if depletion requirements permit; (b) changing the flora—in this instance, using straight sewage rather than the combined flora; and (c) reseeding with lesser volume, e.g., 1 ml. rather than 3 ml.

DISCUSSION

Reseeding is shown by the data to be a reliable means for detecting toxic interference in the B.O.D. reaction.

The reseeding method provides for additions of replacement seed to succeed organisms inactivated by toxic elements in effluents. Such fresh seed carries on the B.O.D. after the toxicant is exhausted. If the curve of the reseeded demand approximates that of the control, toxicity is demonstrated.

The data presented are representative of many tests run while experimenting with various additives designed to lower the B.O.D. of mill effluents. The

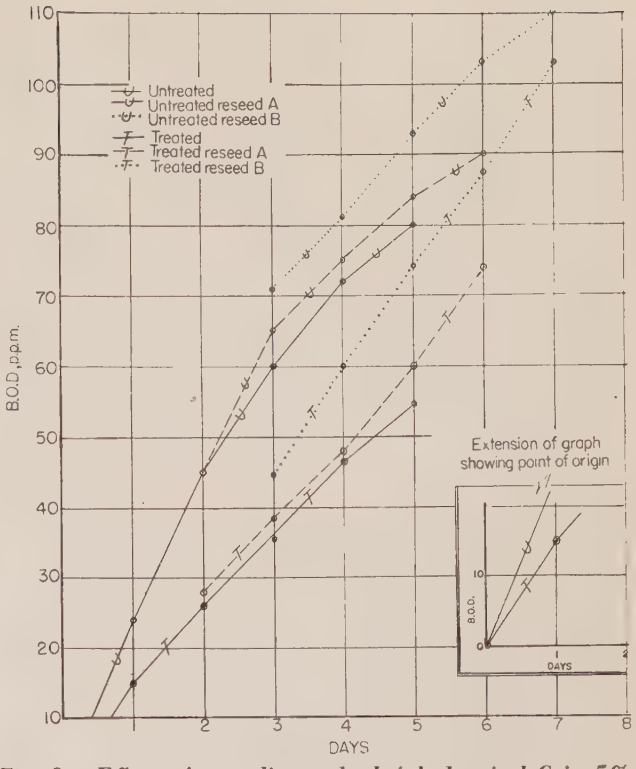

Fig. 9. Effect of reseeding a doubtful chemical C in 5% waste

dosage of these agents was always small, running from 10 to 55 p.p.m. and averaging 17 p.p.m. The change in dilution resulting from new volumes of seed was also small being roughly 1 to 4.5% under schedule A and 1 to 2% under schedule B.

In addition to the major result obtained, that of detecting toxicity, reseeding also showed that: Schedule B usually elevated the demand above that of schedule A even though A was greater than B volumet-

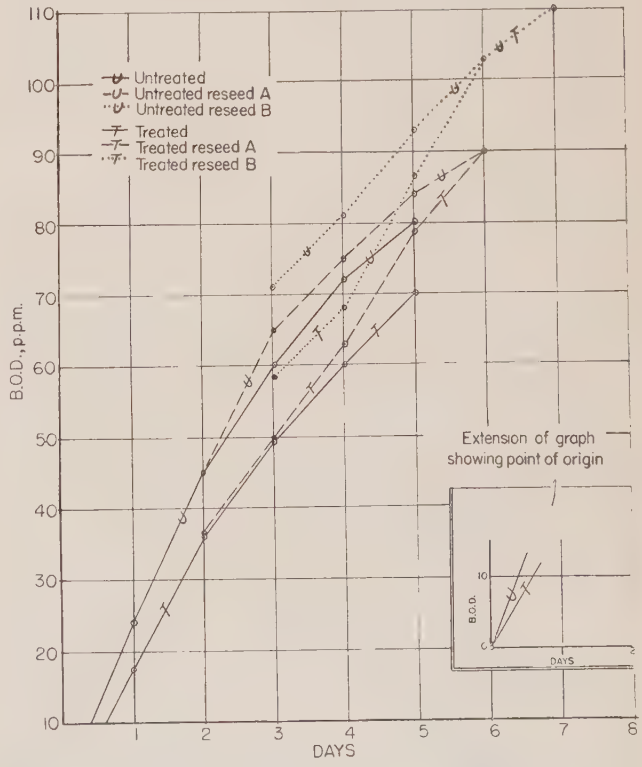

Fig. 10. Effect of reseeding same waste as Fig. 7 with chemical D, also a doubtful toxicant

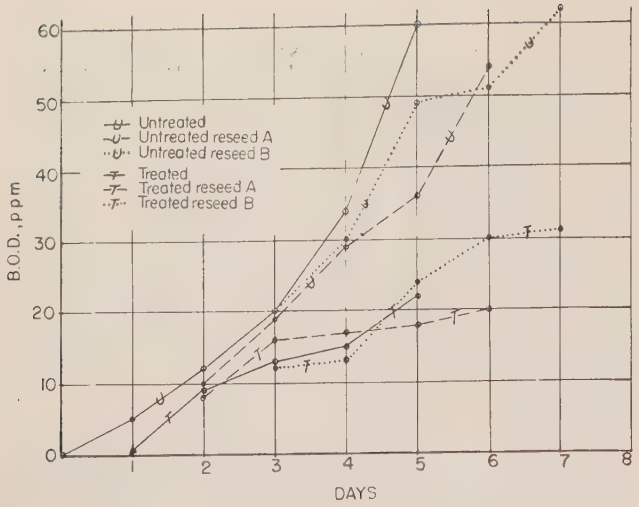

Fig. 11. An example of reseeding depressing B.O.D. values in both untreated and treated waste chemical E

rically. This may mean that in cases of mild toxicity, schedule A overcrowded and disturbed the normal ratio between food concentration and bacterial population correspondingly. Schedule A may also have developed an early ceiling of population in situations of mild and early moderating toxicity. Schedule B, on the other hand, may have encouraged the revitalization of half-life organisms. The curve of schedule B would, in that event, reflect the revitalized metabolism in addition of the normal metabolism of the seed surviving the toxicant.

Some specific results are now noted by specific references to the data:

(a) Compare Figs. 5 and 6. The waste is reseeded beyond the limits of toxic absorption. The uninhibited demand then develops.

(b) Note all the figures in which the reseeded curves follow the same pattern in most instances as that established by the normal B.O.D. For these experimental tests, the "normal" B.O.D. is the determination made by Standard Methods on the plain, untreated effluent.

(c) Note the effect of reseeding in Figs. 6, 8 (severe toxicity) and 7, 9, and 10 (mild toxicity.)

(d) Figure 8 shows how organisms adapted to a media, cellulose in this instance, may accelerate the B.O.D.

(e) A few experiments such as in Fig. 11 have shown that reseeding may depress as well as accelerate B.O.D. values. It may be that such action takes place when a large natural bacterial population is present (as in unchlorinated effluent) or when the treatment is not toxic. In either such situation reseeding would so over populate the media as to inhibit the normal rate of growth. However, even in such cases, reseeding will perform its main purpose, that of determining toxicity.

CONCLUSIONS

The data included in this paper, as has been said, are representative of a great number of applied and experimental tests that have been made by this laboratory on paper mill wastes of many kinds. Daniels (*9*) once authoritatively advised that Mr. Experience was a necessary teacher for all students of B.O.D. An observation out of the authors' experience to date may be useful in view of the pro and con discussions centering around the B.O.D. test. Our work has shown that, given a means of detecting possible inhibitory influences, the B.O.D. is a highly reliable and valuable test for paper mill effluents. Until standardization of seed is achieved occasional vagaries with test results will occur. But, as is known, the problem is in expert hands and a reliable standardization will develop.

Reseeding is a valuable supplement to standard B.O.D. procedures. The authors have yet to see the method fail to reveal even slight lags in demand. Continued work with the method will build up a body of knowledge from which the parts per million toxicity rating of chemicals and agents may be obtained insofar as they operate on parts per million B.O.D.

It is obvious that in applied work, the standard 5-day reseeding result will be sufficient, just as is the 5-day standard result. For most work, reseeding with schedule B would seem adequate, but, when dealing with unknowns, the safeguard of the two schedules is recommended.

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DISCUSSION

B. W. Dickerson (Hercules Powder Co. Wilmington, Del.): The work of Drs. Borden and Woodcock is certainly a valuable contribution to the field of microbiology, and provides a most useful tool for the sanitarian. They are to be commended for their clear thinking in the development of a new method of attack on an old and complex problem, namely, toxicity. In the development of their work they have been able to add new luster to the B.O.D. determination which has received much unfavorable criticism and discredit. Time does not permit a detailed discussion of their work, and comments will be restricted to those most pertinent points.

The authors have been careful in setting up an effective technique for reseeding and have provided every safeguard possible to prevent contamination. Even with the stringent safeguards, the work can be easily performed by any technician familiar with the B.O.D. procedure. However, the nature of the reseeding compartment rather restricts the handling of samples and, when a considerable number are to be

tested, would be time-consuming. It would appear that a modification of this could be made to allow more freedom of movement and thus facilitate the work.

A pertinent point in this report is the manner of seeding, namely, type of seed. The usual practice is with sanitary sewage. The authors have shown with their wastes using this type seed alone, there was considerable lag. The use of straight Musconetcong River water disproportionately accelerated the velocity of the reaction. To overcome the shortcomings of the two types of seed, they combined them and were able to obtain excellent reproducibility. The question arises as to reaction rate with smaller quantities of river-water seed. It would appear that the smaller additions would have been preferable and in keeping with the nature of the work. The river-water bacteria are more nearly acclimated to this general type of waste and toxicant action would be more truly shown.

The method as developed provides an excellent means of detecting toxicity both mathematically and graphically. Wide variations in toxicant strength show up equally well even where dilution has been brought into the picture. It would have been of considerable interest had some of the test work covered wastes in the higher B.O.D. ranges so that a comparison could have been made.

The pollution problem in most industries is not limited to one waste but is complicated by a wide variety of effluents which blended together form the final waste requiring treatment. In some plants, the character of these are well established; in others they are completely unknown and must be thoroughly studied if effective and economical means be established for their purification. In this case one of the first problems in the study is the possibility of toxicity. Sometimes this is known, in others it must be determined.

The methods as developed are very good for determination of toxicity and the establishing of constants for various toxicants in the same terms as the B.O.D. reaction and correlated to it. In this work toxicity was demonstrated graphically if the curve of the reseeded demand approximated that of the control. The control in this case was the B.O.D. curve developed by the untreated sample. In all cases the raw or untreated waste was nontoxic and only the treatment chemical was toxic.

A study of the curves presented on reseeding of the treated wastes containing the toxic material show in general a change of slope, indicative of an accelerated rate of reaction. This is particularly so in the cumulative reseeding. It should be possible through a statistical approach, to develop fixed constants for this increased velocity for various toxicants specific to an industry. The development of such constants would be of inestimable value. However, there would be required a tremendous amount of laboratory work in developing the required data necessary for such compilation. Such an undertaking would of necessity require the services of several laboratories and consume a great deal of time.

In dealing with wastes of unknown composition and toxicity there will be no normal curve available for comparison and a standard for use would need be developed. The use of sanitary sewage as a substrate in the dilution method for toxic substances has been discussed by Heukelekian and is noted in the authors' bibliography. It is suggested that this might be used as a standard or some other well balanced organic material made up in a standard solution. Varying percentages of the new waste would be added to this base. Compensation would then need be made only for the B.O.D. value of the substrate.

It appears that along this path would lay the greatest use for the outlined procedure. Further work, of course, would be required on this phase in order to develop rationalized bases which will permit uniform utilization of the method. In line with the development work suggested, the possibility of determining threshold values of toxicity using cumulative seeding technique arises. By such a method there could be determined in the laboratory the minimum dilution required for acclimatized organisms as would be developed in the actual treatment plant. This level, from our own experience on several toxic wastes, is much lower than indicated by the usual B.O.D. test. The method lends itself admirably to this work and probably only slight modification would be necessary. Such information would then allow the complete picture to be developed, which would materially assist in full scale plant study.

In conclusion a new approach has been made to the problem of toxicity in wastes providing a tool which with continued use and development will add greatly to the solution of complex industrial waste problems.

H. Heukelekian: There is a great need for evaluating and detecting the presence of toxic materials in industrial wastes and if possible to overcome the effects on oxygen demand test. It is however felt by this reviewer that these aims have not been realized by the authors. Specific comments follow:

1. This reviewer agrees with the authors regarding the futility of plating methods in assessing toxicity because low numbers may not necessarily be due to toxic materials and there is not a criterion of numbers of organisms that can be used for reference.

2. The dilution method of B.O.D. determination for assaying the toxicity of wastes has its limitations because the inherent dilution technique to bring the concentration of organic matter within the range of oxygen dissolved in water, may in many instances obliterate the toxicity effect. Thus the effect of toxic materials on the oxygen demand is observable only in a limited range of high dilutions. The examples cited by the authors illustrate this difficulty. Take for instance the example where an apparent increase in B.O.D. is encountered with chemically treated wastes in higher dilutions is contrary to expectations. This is only due to the fact that in order to obtain a B.O.D. of 15 p.p.m. at 2% concentration the depletion must have been 0.3 p.p.m. This is obviously too small a depletion to use for B.O.D. determination and is subject to error. The same criticism can apply to several other such results cited.

These inherent short comings of the dilution method can be overcome by the direct method of assaying the toxicity of industrial wastes as described by the reviewer (*1, 2*). In this method oxygen is not a limiting factor and oxygen demand of wastes can be readily

measured without dilution and at high concentrations.

3. The principles of reseeding technique as proposed by the authors are valid. It is true that many toxic agents become inactivated by reacting not only with the bacterial organic matter as the authors state but by reacting in general with organic and inorganic matter formed in the substrate. The principle of "acclimitization" of organisms to toxic materials is also valid. But the technique developed to overcome the influence of inactivation of toxic materials and to demonstrate the effect of toxic materials on the oxidation rate brought about by "acclimitized" seed has some short comings. Let it be said a painstaking technique has been employed but it is complicated, involved, and laborious. This in itself would not rule out the employment of the method if it accomplished the desired end.

There has been no attempt made to correct for the B.O.D. of the seed added (3 ml. consisting of 1 part of sewage and 2 parts of river water) at the time of original seeding and at each succeeding reseeding. The oxygen demand of this seed itself could be appreciable and can effect the interpretation of the result in respect to toxicity. Specifically, the interpretations of the results given in the table on the basis of the different schedules A, B, C, and A_1, B_1, and C_1 is difficult to follow. $A_1 - C_1 = 29$ p.p.m. $B_1 - C_1 = 42$ p.p.m. The increases in B.O.D. of 29 and 42 p.p.m. can be due to the B.O.D. of the seed material introduced and not necessarily to organisms introduced by successive seeding. It is not clear how the figure 7% increase due to reseeding is arrived at and what it is due to. In any case it is within the experimental error of the B.O.D. technique. It is similarly difficult to follow the other calculations, interpretations and reasoning.

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Abrasiveness Test for Paper Fillers

J. D. MacDONALD and J. W. KENNEY

A considerable amount of data upon which recommendations for standard conditions and procedure for abrasion loss testing of fillers have been based are presented. It is shown that wire type, slurry concentration, slurry pumping rate, length of test, rate of double strokes, wire wear area, and block design influence the abrasion loss test. The necessity of standardizing these conditions seems evident since agreement between different testing laboratories can be obtained through the use of an abrasion standard and adjustment of test conditions.

Wire wear, always an expense item in the paper industry, has become a problem of considerable magnitude in recent years because of faster machine speeds, higher production schedules, and the more wide spread use of inert fillers and paper aids.

In order to facilitate an evaluation of the factors affecting wire wear, various methods and machines have been used by the people concerned. Consequently, abrasion results of dubious value have been circulated throughout the industry. The results by necessity have been relative, and agreement between laboratories has been lacking although the individual results might have been correct if satisfactorily evaluated.

The Valley Iron Works, a pioneer in the field of abrasion testing, developed an abrasion tester, and while no individual tester has been accepted by the industry, the Valley unit is well known and has been used by several members of the industry and its suppliers.

This tester is a machine by means of which wear on test wire is obtained by determining the loss of weight incurred during the test. A weighted and perforated block is rubbed back and forth on the wire while a slurry of the material being tested is pumped through the block and wire. The unit's use, therefore, is limited to those applications where substantially all of the slurry being tested will flow through the screen.

As a result of its interest in developing satisfactory materials for the paper industry, the Dicalite Company, now Dicalite Division, Great Lakes Carbon Corporation, began a study of abrasion loss testing in 1939. After some unsatisfactory attempts to develop its own equipment, the laboratory of this company purchased a Valley Iron Works tester in 1941. Using this unit, the Dicalite Company developed a procedure and technique of abrasion testing on an independent basis, as did other interested concerns. As might have been expected, no one concern's results were in agreement with any other, and the same sample tested in different laboratories was rated from 10 to 1000 mg. abrasion. As a result abrasion data became somewhat worthless, and claims and counterclaims resulted.

In May, 1946, the Dicalite laboratory contacted another user of an abrasion tester, the Appleton Wire Works. After studying the variables involved and through joint action and mutual cooperation, these two concerns were able to obtain duplication of results on the same sample.

Because of the desirability of standardizing a test of major concern, and because it has been demonstrated that standardization is possible, this study is presented. In so doing, the authors wish to acknowledge the invaluable cooperation of John Gerhauser of Appleton Wire Works. They also wish to acknowledge the assistance provided by the Valley Iron Works. This paper will present a study of the variables involved in abrasion testing, recommendations for a standard test, and applications of this study to wire wear.

J. D. MacDonald and J. W. Kenney, Dicalite Division, Great Lakes Carbon Corp., Los Angeles, Calif.

ABRASION STANDARD

The earliest efforts to determine abrasion loss provided evidence that a considerable number of variables had to be controlled and their effects investigated, therefore, the necessity of selecting a satisfactory standard material to be used in the study was realized. In order to avoid deviation to an artificial approach, it was desirable to select a material accepted by the industry as satisfactory from the standpoint of abrasion. It was also desired that the material have a degree of abrasiveness which would permit comparison with other products having both lower and higher abrasion. After evaluating numerous materials a standard was selected which had an abrasion loss in the range of 85 to 101 milligrams according to the test procedures used at that time. Despite the many changes in procedure which were decided upon, adjustment of the variables has made it possible to maintain the standard in the same range continuously. It is believed that the early recognition of the necessity for a standard and its selection was most fortunate since it has been possible to obtain directly comparable and consistent data through the years. In other words, current results are practically identical to those of the past. This has minimized confusion to the industry, the testing laboratory, and to the production department in their efforts to improve their processes and products.

INVESTIGATION OF VARIABLES

While certain characteristics of the individual testing unit are necessarily constant by virtue of design, the actual test conditions can be varied at the discretion of the individual operators. The effects of changing test conditions are of considerable magnitude as will be shown in the following discussion.

Effect of Wire Type on Abrasion Loss

Number of double strokes, 6000; double strokes per minute, 101; concentration, 100 g./3200 ml., drilled block, Valley Iron Works design.

Material tested	*Wire* — *Weave*	*Wire* — *Mesh*	*Abrasion loss, mg.*
Dicalite standard	Plain	70 × 50	86
Dicalite standard	Twill	60 × 40	324
Coating clay	Plain	70 × 50	10
Coating clay	Twill	60 × 40	48

The above results demonstrate that the type of wire used can cause approximately a four fold difference in the abrasion value reported. The twill weave wire* was adopted for the test because it is easily obtained. This wire has been found to be sufficiently uniform for test purposes and is widely used throughout the industry.

The following results show that the abrasion loss is roughly proportional to the slurry concentration. A slurry concentration of 50 grams/3200 ml. was adopted. This practice conserves sample for additional tests, provides ample accuracy without unusual precautions, and minimizes wear on the machine and slurry pump.

* 60 × 42 Twill weave Phosaloy. Warp wire diameter 0.00925 in.: 8.0% tin, 0.3% phosphorus, 91.7% copper. Shute wire diameter 0.0115 in.: 20% zinc, 80% copper.

Effect of Slurry Concentration on Abrasion Loss

Wire, twill weave (60 × 40 mesh); drilled block, Valley Iron Works design; double strokes per minute, 101.

Material tested	*Double strokes total*	*Concentration, g./3200 ml.*	*Abrasion loss, mg.*
Dicalite standard	6000	50	152
Dicalite standard	6000	100	324
Dicalite standard	2500	25	51
Dicalite standard	2500	50	93
Dicalite standard	2500	75	125
Dicalite standard	2500	100	160
Coating clay	6000	50	22
Coating clay	6000	100	48

Effect of Number of Double Strokes on Abrasion Loss

Wire, twill weave (60 × 40 mesh); concentration, 50 g./3200 ml.; drilled block, Valley Iron Works design; double strokes per minute, 101.

Double strokes, No.	*Abrasion loss, mg.*
1000	45
1250	48
1500	58
2000	79
2500	93
3000[a]	105
4000[a]	137
5000[a]	161
7500[a]	242

[a] Average values.

As might be logically expected, the abrasion loss is nearly directly proportional to the total number of double strokes. The authors have adopted 2500 strokes for the test because at this point it was possible to obtain consistent data and because the length of time required is relatively short. The shortened test interval facilitates quality control and permits more testing.

Effect of Wear Area of the Screen on Abrasion Loss

Number of double strokes, 2500; concentration, 50 g./3200 ml.; wire, twill weave (60 × 40 mesh); double strokes per minute, 101.

Block surface	*Block size, in.*	*Screen wear area, in.*	*Abrasion loss, mg.*
Drilled[a]	$3^{11}/_{16} \times 3^{1}/_{16}$	$7^{3}/_{4} \times 3^{1}/_{16}$	93
Smooth[b]	$3^{1}/_{16} \times 3^{1}/_{16}$	$7^{1}/_{8} \times 3^{1}/_{16}$	82

[a] Drilled—1/8-in. holes drilled through surface of block.
[b] Smooth—Surface not drilled. Five 3/8-in. holes through lead edges of block.

It is the authors opinion that the differences shown are caused by screen wear area and not the block surface. The drilled block was standardized upon, however, partially because the smaller block did not run well in the unit used. It wore more rapidly at the ends and tended to rock instead of slide. This probably is because of its tendency to push the slurry to the edges of the test wire. This latter tendency causes low results on those samples containing relatively coarse particles as these particles are forced completely off the wear area of the wire and fail to exert their true effect on the abrasion loss.

The following data demonstrate that the slurry pumping rate has little effect on the abrasion loss provided it is uniform and sufficiently high to prevent settling in the unit. The authors' machine was modified somewhat by discarding the provided diaphragm pump for a rubber impeller rotary pump since experience indicated that improved accuracy resulted. A pumping rate was adopted of 2700 ml./min. This rate is sufficiently high to eliminate low results;

Effect of Rate of Slurry Flow on Abrasion Loss

Series 1

Number of double strokes, 6000; concentration, 100 g./3200 ml.; wire, plain weave (70 × 50 mesh); drilled block, Valley Iron Works design; double strokes per minute, 101.

Slurry rate, ml./min.	*Abrasion loss, mg.*
400	65
800	74
950	71
1000	79
1080	88
1300	83
1800	88
2200	84
2700	86

Series 2

Number of double strokes, 2500; concentration, 50 grams/3200 ml.; wire, twill weave (60 × 40 mesh); drilled block, Valley Iron Works design; double strokes per minute, 101.

Slurry rate, ml./min.	*Abrasion loss, mg.*
500	72
650	85
800	97
1000	92
1500	94
2500	96
3500	90
4000	98

significantly higher rates tend to splash slurry out of the machine and show no particular advantage.

Effect of Rate of Travel of Abrading Block

Number of double strokes, 2500; concentration, 50 g./3200 ml.; wire, twill weave (60 × 40-mesh); drilled block, Valley Iron Works design; double strokes per minute, 101.

Double strokes/min., No.	*Abrasion loss, mg.*
101	93
60	76
30	68

The above data demonstrate that the rate of travel of the abrading block has considerable effect upon the abrasion loss reported. The higher rate gives higher abrasion loss values. The authors have been forced to adopt 101 double strokes per minute because their machine is so designed, the lower rates having been obtained by using a variac on the drive motor.

WIRE LIFE

Experience indicates that the individual test wires can be used a considerable number of times. A series of checks using the standard indicate that consistently accurate data are obtained up to 15 consecutive tests on the same test wire, or approximately a 1500 mg. loss.

As a matter of interest, a series of results showing the degree of wear necessary to produce failure of the test wire was included. These data, while pertinent, are based upon earlier procedures now discarded, therefore, direct comparison with the previous data of this report are not justified. The end results, however, and the relationships between weight loss and thickness loss are reliable.

The following data indicate that failure of the test wire occurred at approximately 3000 mg. weight loss and 0.0170 inch wire thickness; at this thickness the average thickness wear was 0.0081 inch.

Wire Wear Data

Wire, twill weave (60 × 40 mesh); block, smooth surface; concentration, 64 g./3200 ml.; double strokes per minute, 101.

Time, min.	*Strokes, No.*	*Initial thickness, in.*	*Final thickness, in.*	*Wear, in.*	*Wear, mg.*
6	625	0.0269	0.0263	0.0006	36
12	1,250	0.0269	0.0261	0.0008	66
24	2,500	0.0268	0.0258	0.0010	103
72	7,500	0.0269	0.0253	0.0016	214
120	12,500	0.0269	0.0251	0.0018	268
168	17,500	0.0270	0.0250	0.0020	316
335	34,800	0.0250	0.0224	0.0026	505
1000	104,000	0.0250	0.0197	0.0053	1679
1550	161,276[a]	0.0250	.....	.....	2774
1594	163,776[a]	0.0250	.....	.....	2895
1750	182,000[a]	0.0250	0.0166	0.0084	Failure, no weight obtained
1664	173,000	0.0250	0.0173	0.0077	Failure, no weight obtained
		Data vs. Distilled H_2O Alone			
110	11,100[a]	0.0250	.....	.....	10
1750	182,000[a]	0.0250	0.0241	0.0009	15

[a] Same screen.

Based upon experience and the considerable data which have been accumulated the following test conditions and procedure for abrasion loss testing have been adopted and are recommended:

Test unit.....Valley Iron Works Abrasion Tester 201-15-E, 1937
Stroke length, in.....4
Block weight, g.*.....8355
Block wear area, in.....$3^1/_{16} \times 3^{11}/_{16}$
Wire wear area, in.....$3^1/_{16} \times 7^8/_4$
Pump.....Rotary, rubber impeller
Test wire.....Appleton twill weave, (60 × 40 mesh)
Double strokes, total.....2500
Slurry concentration, g./3200 ml.....50
Slurry pumping rate, ml./min...2700
Block composition.....Micarta
Block type.....Drilled, Valley Iron Works design

* Minus drive arm.

TEST PROCEDURE

1. Cut a suitable screen, 10 by $4^5/_8$ inches. The 10-inch dimension is along the direction of the long knuckle of the warp wire on the suction box or wear side of the wire. Press the screen into position in the unit by bolting into place with the wear side up. Remove the pressed screen from the unit. Cut triangular portions from opposite corners of the clamping, not wear area, of the screen. Pierce two small holes in the screen for suitable suspension in the analytical balance from a tared hook. Mark the screen identification off the wear portion of the wire with India ink. Wash the screen in clean Stoddard solvent, rinse thoroughly with water, blow dry with compressed air, and place in an oven at 105°C. for 30 minutes. Remove from the oven using a paper towel, weigh the screen to 1 mg., and record weight.

Bolt the weighted screen into place in the unit. Place block in position on the screen and fasten to drive arm. Check that stroke counter is at zero.

2. Transfer 50 grams of sample, thoroughly dispersed in 3200 ml. of distilled water, to the test unit through the perforated block, being particularly careful to avoid spilling the slurry outside the block area.

3. Pump the slurry through the block for a few minutes to check on coarse portions which might fail to pass through the screen, utilizing the pumped liquor to affect complete transfer of slurry to the unit. Stop pump momentarily to allow the block to drain. Then start pump and block motion simultaneously. Set electrical clock switch for 24 minutes. This will shut off between 2400 and 2500 strokes. Restart and run to exactly 2500 strokes before shutting off pump and block motion.

4. Remove test slurry through water aspirator and remove block and screen. Rinse unit thoroughly with clean tap water while running the pump and remove wash water through aspirator. Continue rinsing until wash water is perfectly clear.

5. Wash the screen with tap water; brush any particles stuck in meshes from the screen with camel's hair brush. Blow screen with compressed air and place in oven for 30 minutes at 105°C. Remove screen from the oven with a paper towel. Look through the screen toward the light and remove any adhering particles from screen mesh with a needle. Weigh screen to 1 mg.; record weight. Subtract final weight from original weight. Report the difference as abrasion loss in milligrams.

6. Reset counter to zero and cover the unit to avoid external contamination.

Accuracy of Procedure

Using the test method and conditions outlined above 39 runs were made on the standard to establish the accuracy of the procedure. An average value of 93 mg. with a standard deviation of ±8 mg. was obtained. Less extensive tests of more recent origin indicate improved accuracy, probably because of technique improvement based upon more familiarity with the procedure. This value of 93 ± 8 mg. on the standard is customarily used to check the operation of the test unit. With the test unit checked satisfactorily, an average of two runs will give a suitable abrasion value on an unknown sample.

The deviation from 93 mg. ran from 0 to ±12 mg. Standard deviation was calculated from a formula appearing in *Chem. & Met.*, June, 1946.

$$\text{Standard deviation} = 5/4 \frac{\Sigma D}{n - 0.8} = 5/4 \times \frac{236}{38.2} = 8 \text{ mg.}$$

where ΣD = the sum of the differences from the average, and n = the number of determinations.

Agreement with Appleton Wire Works

About May, 1946 the Appleton Wire Works were contacted to seek agreement on abrasion loss testing. At first it was apparent that various differences existed, namely, in block surface and size, in stroke length, in rate of strokes per minute, and in slurry concentration.

For a first approach, the Dicalite laboratory fabricated and used a smaller, smooth surface block similar to Appleton's. At the same time the slurry concentration was raised to meet the Appleton concentration. These moves resulted in agreement on abrasion loss on the standard sample when running at 2500 double strokes and 64 g. per 3200 ml. slurry concentration. Dicalite reported an average value of 92 mg. and Appleton an average value of 93 mg. Unfortunately, as previously mentioned, the smaller block did not run well in the authors' unit and was replaced with the original larger drilled block. Seemingly, this would upset the agreement. However, all that was necessary to again effect agreement was for the Dicalite laboratory to return to a slurry concentration of 50 grams per 3200 ml.

With more exact knowledge of existing differences the pattern of the agreement became clear. The differences in block size and stroke length between the two test units balanced one another as practically the same screen wear area was found. The difference in rate of strokes per minute between the two machines was the influencing factor, Appleton running at 45 strokes per minute and Dicalite at 101 strokes per minute. From the data shown on rate of strokes per minute, interpolating for the 45 strokes per minute value, the effect of this difference on the abrasion loss of the standard would be:

Number of double strokes min.	*Abrasion loss, mg.*
45	72
101	93

This difference in abrasion loss was compensated for by the difference in slurry concentration. The following summation shows the differences and final agreement.

Test wire, twill weave, (60 × 40 mesh); number of double strokes, 2500.

	Appleton	*Dicalite*
Block surface	Smooth	Drilled
Block size, in.	$3^1/_{16} \times 3^1/_{16}$	$3^{11}/_{16} \times 3^1/_{16}$
Stroke, in.	$4^1/_2$	4
Screen wear area, in.	$7^5/_8 \times 3^1/_{16}$	$7^3/_4 \times 3^1/_{16}$
Strokes per minute	45	101
Concentration, g./3200 ml.	64	50
Abrasion loss	93	93

SUMMARY

Actually no direct correlation has been established between the abrasion values obtained with the previously described test and wire wear in the mill. The accelerated conditions of the abrasion test are certainly much more severe than the conditions encountered on a plant basis.

In terms of filler concentration, for example, mill slurries are much less concentrated. In fact, the complete stock concentration, including the relatively low filler percentage, approaches the concentration of the test's filler slurry alone.

Recently the authors had occasion to check the abrasiveness of a wire pit white water containing 3% of added filler and 10% of waste paper stock. The abrasion loss on the test wire was found to be 46 mg. This value dropped to 5 mg., however, after the large fibers were screened out on the regular 60 by 40-mesh screen used as a test wire. This indicated that the abrasive portions of the fibers and filler are chiefly retained in the sheet.

Tests on distilled water alone further illustrate that wire wear is chiefly caused by the furnish for even after 182,000 strokes these conditions produced only 15 mg. abrasion.

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Sodium Silicates in the Paper Industry

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This paper is a summary of much of a prominent producer of sodium silicate's experience and practically all the pertinent literature references regarding the numerous applications of sodium silicates in the pulp and paper industry. Special reference is made to uses for sizing, coating, deinking, rag and straw cooking, bleaching, and water treatment.

Sodium silicates are compounds or systems containing alkali (Na_2O), silica (SiO_2), and water in varying proportions. The variety of useful properties shown by the more than fifty compositions commercially available and their low cost has led to the development of numerous practical applications for these materials in the paper industry. Properties of those products of most interest in paper mill applications are summarized in Table I. The alkaline silicate, sodium metasilicate and sesquisilicate, are definite stoichiometric crystalline chemical compounds which dissolve readily in water. The more siliceous sodium silicates are usually glasses of continuously varying ratio rather than definite compounds. They become increasingly difficult to dissolve with increasing silica to alkali (Na_2O) ratio. Those with a ratio of 1.6 or greater are usually dissolved by the manufacturer using steam under pressure and sold in the form of solutions which are as concentrated as viscosity and working conditions permit. Uses for the siliceous colloidal silicates in paper mills include applications in sizings, coatings, peroxide and hypochlorite bleaching, cements, adhesives, clay deflocculation, boiler water treatment, and corrosion prevention. The more alkaline silicates are used in deinking and for other detergent applications as well as for straw and rag cooking.

SIZING

A patent on the use of sodium silicates in the sizing of paper was issued as early as 1864 to van Derburgh who recommended the use of a 35 to 40° Bé silicate with a silica to alkali (Na_2O) ratio of 2.9 to 3.3 (*93*). Fleury in 1866 revealed the addition of glue or albumen and sodium silicate to paper pulp followed by the addition of a soluble sulphate or sulphuric acid to give a fire resistant paper (*35*). Some American mills were using silicates in their sizings in 1876. In 1880, Ehrhardt disclosed sizings consisting of approximately 2 gallons silicate of soda, 4 to 5 pounds of alum, and 8 to 10 pounds of zinc chloride (*31*). In Germany the use of sodium silicates in paper sizings was studied by Klemm and others around 1909 (*6, 53*).

Extensive laboratory investigations on this subject were begun before World War I by T. E. Blasweiler under the direction of Emil Heuser but the complete results and review of the literature were not published until 1922 (*6*). Blasweiler showed that somewhat more than $^1/_3$ as many moles of aluminum sulphate as of Na_2O, $3SiO_2$ was required to precipitate the silicate satisfactorily. The precipitate formed was but slightly soluble under conditions similar to those existing in a paper beater. A higher per cent retention of the precipitate on the paper was obtained with increasing silicate and alum concentrations. Silicate sizings, both alone and with other sizings such as rosin, starch and glue, increased the retention of such fillers as china clay and talc. Both alone and in mixtures with rosin, starch, and glue silicate produced an increase in the breaking strength of the paper. The papers obtained showed good capillary rise both for water and oil and were particularly suitable for printing with oily inks. The use of metasilicate instead of the siliceous silicates with ratios between 3 and 4 was less effective and more expensive. Magnesium sulphate was not a satisfactory precipitating agent for the silicate. In spite of increased filler retention silicate-sized papers had breaking strength greater than those containing no silicate sizing. Rosin-silicate mixtures should contain enough alkali for saponification and neutralization of the rosin without the separation of a hydrous silica. Such mixtures gave paper of better whiteness than rosin alone. These papers did not turn yellow on exposure to sunlight. Silicate sizings containing less than 1% fatty acids gave good results but amounts of fatty acids greater than this decreased the strength, handle, rattle, and printing qualities of the paper. Casein was not recommended as an internal size either alone or mixed with silicate.

Plant scale experiences for more than seventy years have shown the benefits produced under proper conditions by adding sodium silicates in the beater and precipitating them with alum. Sodium silicates increase the rate of hydration of the cellulose fibers thus giving greater hydration in a shorter time. One mill producing a 100% manila envelope reports that the use of silicate made possible a reduction in their beating cycle from 1.5 to 1.0 hours. Another states that the beating cycle of a different type of furnish could be reduced from 4.1 to 3.6 hours whereas a third reports a saving of 5 to 10%. The extent of hydration is controlled by the amount of silicate used and the length of time between its addition and the precipitation with alum. Such effects result in larger production and a reduced unit cost.

Other mills use 1 or 2% of the 42°, 3.2 ratio silicate on the weight of the air-dry pulp for pitch control. The pitch is kept dispersed in the beater, and precipitated with alum in a useful form as part of the sizing. It does not adhere to the wire of the machine. Sodium silicates saponify oleoresinous pulps (*39*).

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Table I

Name	*Formula*	*SiO_2/Na_2O weight ratio*	*% Na_2O*	*% SiO_2*	*Specific °Bé*	*Gravity, g./cm. 20/20° C.*	*Approx. viscosity, poises 20° C.*
Sodium sesquisilicate	$Na_3HSiO_4 \cdot 5H_2O$, or $3Na_2O \cdot 2SiO_2, 11H_2O$	0.65	37.0	23.8	..	..	..
Sodium metasilicate pentahydrate	$Na_2SiO_3 \cdot 5H_2O$	0.97	29.2	28.3	..	..	..
BW	$Na_2O \cdot 1.7SiO_2$	1.60	19.5	31.2	58.5	1.68	70
RU	$Na_2O \cdot 2.5SiO_2$	2.40	13.8	33.1	52.0	1.56	17
Seal	$Na_2O \cdot 3.0SiO_2$	2.90	11.0	31.9	47.0	1.48	9.6
N	$Na_2O \cdot 3.3SiO_2$	3.22	8.90	28.7	41.0	1.39	1.8
O or "A Syrup"	$Na_2O \cdot 3.3SiO_2$	3.22	9.16	29.5	42.2	1.41	4.0
Stixso DD	$Na_2O \cdot 3.5SiO_2$	3.40	8.30	28.2	39.7	1.38	3.3
S special	$Na_2O \cdot 3.8SiO_2$	3.75	6.75	25.3	35.0	1.32	2.2

After precipitation of the silicate with alum in the beater, the first obvious effect is an improved finish on the paper produced. It feels smoother and has less fuzz and loose fibers. Tests show that the strength of the paper, as measured by such standard tests as the burst, tear, tensile, and folding strengths, is increased. Usually the increase in the burst or pop test is about 10%. One plant test of 1200 samples from 550 tons of cover paper showed an average increase of 12% in the bursting strength test. In another large scale test in Britain on newsprint an increase of 5% was obtained in spite of a 64% retention of filler (*37*). Other mills report a 5 to 11% increase on a 25-pound waybill, and an 8 to 10% increase with an offset paper. In some cases the pop test is not increased by the silicate although the use of silicate may be justified by other results.

Another result of sizing with sodium silicate and alum is an increase in the hardness and rattle of the paper. The sheets produced are firmer, stiffer, and have less tendency to curl. An important result is the increased retention of short fibers, rosin, starch, and clay or other filler which may be present. In one mill the retention of clay was increased 10% by the use of silicate. During the war a mill producing a sulphate paper with 4% rosin size replaced this with 1% rosin and 3.5% 42° Bé, 3.2 ratio sodium silicate with improved results and a 75% saving of rosin. Increased retention of rosin size when silicate is used results in increased water resistance of the paper although the silicate itself does not directly produce this effect. Silicate sizings do however increase resistance to oils and printing inks. Paper sized with silicate usually has an improved color and is less likely to yellow with age.

Use of silicate-alum sizing frequently results in an increased production of paper which more than pays for its cost. This results from retention of the silicate-alum precipitate which contains about 25% water, and increased retention of fillers and short fibers. Use of 4% silicate usually results in an increase of 1% in the ash corresponding to 70 to 85% retention.

The amount of the 42°, 3.2 ratio or 35°, 3.7 ratio silicate used for paper sizing varies from 2 to 8% of the weight of the air-dry pulp. Usually the silicate is added to the beater along with or just after the fibers although rosin may be added first. After the silicate is thoroughly mixed and the stock hydrated to the desired extent, sufficient alum is added to precipitate it. This requires 33 pounds of papermakers alum per 100 pounds of the 42°, 3.2 ratio silicate or 27 pounds for the 35°, 3.7 ratio product in addition to that needed to precipitate rosin or other ingredients of the furnish. The addition of alum is probably best controlled by using sufficient to reduce the pH to approximately 4.5. The more siliceous silicate is recommended because less alum is required to effect precipitation and a higher percentage of the silicate is usually precipitated and retained in the sheet. The precipitate formed when alum is added to sodium silicates probably consists of hydrated aluminum silicates with some colloidal silica and alumina.

Silicate-alum sizing is being used for a wide variety of papers. It is added with rosin and with or without starch to bristol board to give a stiff smooth surface. The increased strength and reduced mechanical treatment needed to effect hydration led to its use in kraft papers. In book papers silicate sizing increases clay or talc retention without loss of strength whereas in straw it produces a stronger denser sheet at lower cost. Its use in envelope and offset papers is to improve the finish, in greaseproof and glassine papers to increase hydration, and in writing papers to give better finish and formation.

Materials which have been added to silicates to improve the water repellency include paraffin, carnauba, or Montan waxes (*17, 58*); waste wax paper (*14*); asphalt (*23, 52*); petrolatum (*71*); rosin soaps, alkali oleates, and asphalt (*29*); fatty acid soaps (*18*); and a mixture of glue, and paraffin dispersed in the silicate (*19*). Other silicate sizing mixtures include a special starch treatment (*60*); paraffin, rosin, and calcium carbonate (*87*); molten coumarone-indene resins (*50*); oxidized paraffins (*33*); a metal salt such as zinc chloride giving a white oxide followed by treatment with acid (*81*); an organic adhesive such as glue containing 1 to 7 parts of a filler such as clay (*64*); and a mixture of 14 parts kaolin, 14 parts calcium carbonate, and 2 parts formalin (*8*).

Baker and Dedrick (*3*) describe the use as paper sizes of activated silica sols similar to those employed in water treatment (*62*). These silica sols are precipitated with about $^1/_5$ the amount of alum used to precipitate sodium silicates as sizings to give a hydrated size which on an anhydrous basis is 89 to 98% colloidal silica with the remainder being alumina. The retention of this size is considerably greater than that with the unneutralized silicate. In a plant test 40 pounds of 42°, 3.2 ratio silicate were diluted, partially neutralized with sulphuric acid, allowed to age, and then added to a beater containing 250 pounds sulphite pulp, 750 pounds groundwood, 100 pounds clay, and 8 pounds rosin and water. The basis weight, burst test, and bulk were practically the same as those

obtained with the same amount of silicate by the conventional sizing method. However, resistance to the sugar-dye solution in the Bureau of Standards test increased from 40 to 47 seconds, the formation as measured on the Gurley densometer increased from 57 to 77, the ash was 5.40% as compared with previous values of 4.75, the per cent retention was 68% instead of 60%, and the clay and fiber in the white water decreased from 9.97 to 7.33 pounds per 1000 gallons (*3*).

The recommended method of using starch with silicate is to heat an equal weight of starch in 20 to 60 pounds of either the 42°, 3.2 ratio or the 35°, 3.7 ratio silicate (previously diluted with 25 to 30 gallons of water) until the starch just begins to swell. The mixture is then cooled rapidly to prevent further swelling and added to the beater. Recently Fowler and Pattilloch have disclosed a precipitable sizing for paper pulp consisting of substantial quantities each of starch, rosin or rosin size, and the alkaline sodium meta- or sesquisilicates (*36*). A mixture of 40 parts of starch, 50 parts of a urea-formaldehyde condensation product, and 20 parts sodium metasilicate is claimed to give improved sizing and a marked increase in wet and dry strengths. Other alkalies do not give the same results as the silicates (*36*). Pattilloch has also patented a paper size consisting of protein containing cereal flour, rosin or rosin size, and meta- or sesquisilicate (*70*).

Sodium aluminate has also been used to precipitate sodium silicates in sizing paper. One mill adds 80 pounds of the 39.7°, 3.4 ratio silicate per ton of dry pulp and precipitates this with 10 pounds of sodium aluminate in order to stiffen a straw corrugating medium.

COATINGS

Siliceous sodium silicate solutions with specific gravities between 1.12 and 1.15 were used by Artus in 1857 to coat paper to replace wax paper used in packaging pharmaceuticals (*2*). O'Connor in 1880 patented the manufacture of a flexible fire resistant paper by coating paper with siliceous sodium silicate solutions with specific gravities between 1.10 and 1.25 at 62°F., then passing the paper between pressure rolls to remove liquid not absorbed by the paper, and heating to dry (*68*). Philipp's 1884 patent (*73*) describes the production of an inexpensive water-resistant metal coating by applying a mixture of 60 parts powered rosin, 15 parts alcohol, 10 parts of a petroleum fraction, and 5 parts silicate of soda, and then spreading metal dust on it before the mixture is dry. A fire-resistant paper or board was made in 1887 by Merrill by coating with silicate of soda a paper containing 60% vegetable fiber, 20% asbestos fiber, 10% alum or copperas, and 10% lead oxide, lamp black, or Venetian red (*61*). Bird in 1885 used a mixture of resin, paraffin, and sodium silicate to waterproof paper (*5*).

Wesener's 1898 patent (*96*) describes the preparation of a "germproof" filter by impregnating paper thoroughly with solutions of a siliceous silicate, and squeezing free the excess liquid. The treated paper is then immersed in a solution of an acidic material to precipitate hydrous silica in the pores of the paper giving a product resistant to the passage of water. Paper or cardboard was made greaseproof by Randolph in 1901 by coating with a complex paste consisting of 11 pounds sodium silicate, 1/4 pound mica, 10 ounces glycerine, 1/4 pound sugar, 4 ounces rice flour, 4 ounces gum arabic, and 2 ounces prepared chalk (*74*). The same year Gordon (*40*) patented a composition for making paper fire resistant consisting of 1 gallon silicate of soda, 10 pounds sodium hydroxide, 5 pounds sodium carbonate decahydrate, 10 pounds sodium chloride, and 1 gallon of water. Water-resistant cellulose articles were made by impregnation with hot aqueous alkaline silicates followed by rapid drying (*80*).

At the present time papers are coated with sodium silicates in order to increase their stiffness, moisture, fire, and grease resistance, and in some cases to decrease their tendency to adhere to sticky surfaces such as raw rubber sheets. All types of papers can be coated with silicates satisfactorily under proper conditions; those most commonly used now are chip, straw, manila stock and the mixture of mechanical and chemical pulps frequently called "jute," although it contains no jute or manila fiber. Silicate coated papers are used in packaging foods containing fats and oils such as butter, crackers, cookies, and candy. Liquid products such as oysters, ice cream, milk, pickles, oils, and greases are handled in silicate-coated containers. When considerable moisture resistance is desired, a paraffin coating is placed over the silicate. Coffee and spices retain their aroma better in packages from silicate-coated paper (*92*).

The siliceous silicates used for coating are first diluted sufficiently to allow them to penetrate the paper. Coating is most easily done when the paper is unsized or lightly sized. Wax and resin sizes are to be avoided if possible. Greater grease resistance is obtained if the paper sizing contains silicate. The optimum dilution varies with the paper. The solution must be diluted enough that the silicate penetrates well and is absorbed by the paper. Greater dilutions should be avoided since the amount of silicate solids in the coating is reduced and more water must be removed by drying and by absorption into the paper. Usually the dilution is 3 or 4 volumes of silicate per volume of water. The most siliceous silicates are recommended for coatings since they form films which dry faster, are more moisture and grease resistant, and have less tendency to stain alkali-sensitive papers. The 35°, 3.7 ratio silicate gives best results but the 41.0 and 42.2°, 3.3 ratio products are widely used.

Silicate coatings are generally applied as a separate operation on coating or paraffining machines. The paper is passed between two revolving steel or rubber rolls. The lower roll dips into a pan set underneath which contains the diluted silicate. If both sides are to be coated the upper roll which is sprayed by a series of small pipes is so set that it will spread the solution on the upper part of the board. Usually the best method of coating both sides is to run the paper directly through the silicate itself. Novak's process (*66, 67*) involves saturating the wet web of the paper with silicate. The amount of silicate applied by the

various treatments is controlled by the pressure and distance between the steel squeeze rolls. Relatively high pressures are used so that no excess silicate will be left on the surface to give a brittle coating which will crack and to drive the silicate into the fibers to give a greater degree of grease resistance and a more flexible film.

Thin silicate films set rapidly and air drying is usually sufficient. Coating machines may be operated at speeds up to 300 f.p.m. or more if 10 to 20 feet of drying space are present. Speeds up to 500 f.p.m. have been used when drying rolls or tunnels are provided.

Some mills apply a silicate coating in the water boxes on the calender stack of the paper machine. This is not generally recommended since the results are usually not as good as in a separate operation and, unless great care is taken, silicate may form a hard-resistant film on the steel calender rolls. When this method is used the silicate should be diluted with at least an equal volume of water, and the boxes and calender rolls thoroughly cleaned with steam immediately after the machine is shut down.

The amount of silicate per 1000 square feet varies from 2 pounds for light coatings such as those used prior to coating with paraffin to 6 to 8 pounds for cracker boxes, and as much as 20 pounds or more for heavy greaseproof coatings.

Numerous substances have been added to sodium silicate coatings to increase their water resistance and to increase flexibility and fire-resistance. There are also patents claiming methods of minimizing the tendency of silicate films to absorb carbon dioxide from the air thus becoming white and losing their transparency. If this occurs the silicate coating is too heavy or has been exposed to carbon dioxide or combustion gases before drying. Well-made silicate coatings show no white. The addition of 3 to 25% of various sugar or honey solutions, or 2 to 10% glycerine, starch, or rubber latex increases flexibility. Water resistance is increased by reaction with heavy metal oxides or acidic materials. Silicate films may also be overlaid with paraffin, chlorinated naphthalenes, rubber or other high-polymer latices, waxes, gums, nitrocellulose lacquers, or other colloidal films which are not easily saponified.

An early silicate coating mixture particularly designed for greaseproofing was a paste of 11 pounds sodium silicate, 4 ounces mica, 10 ounces glycerol, 3 ounces dextrin, and sufficient chalk to thicken the mixture (*16*). According to a patent, a glassine or imitation parchment paper can be produced by coating the web with a mixture of 20% cerelose, 4% sodium metasilicate, 20% glycerin, and 56% water prior to complete drying. The cerelose gives whiteness whereas the metasilicate produces the sheen. Passing the paper through a 2 to 5% metasilicate solution before supercalendering is claimed to give further transparency, sheen, and glassiness although not producing a coating in the usual sense (*4a*). A more recent patent covers the use for greaseproofing of wax plasticized with glycerin, cerelose, sodium metasilicate, and water (*4b*). Petroleum containers may be made by coating the inner wall of paper tubes with 80 to 95% of a 3.2 ratio silicate, 15 to 25% glycerol, 0 to 2% corn syrup, 1 to 4% gum arabic, and 0.2 to 0.5% potassium oleate (*46*). The addition of 3 to 5% of finely divided hygroscopic bentonite to the sodium silicate is claimed to increase water and grease resistance as well as improve flexibility (*26*). Similarly coating with silicate a paper containing spent lime cooking liquors (*21*) or lime and asbestos (*24*) improves stiffness, and water and grease resistance but may lower flexibility. A series of patents (*88, 90*) covers the greaseproofing of paper with mixtures of sodium silicates and a polyhydric alcohol or rubber latex. Several coats of decreasing rubber latex content may be applied.

Other patented compositions are directed toward the production of a coated paper to which sticky or tacky materials such as raw unvulcanized rubber sheets do not adhere. One of these adds a layer of rubber on a coating of silicates, dextrin, and glycerol (*41*). Another impregnates the paper with the silicate and then partially neutralizes the alkali of the silicate with an acid (*94*). Impregnation of the paper with a soap-wax dispersion followed by coating with silicate is also reported effective for this purpose (*85*). Special mixtures for this application include 140 parts sodium silicate, 15 parts glycerine with a small proportion of a wax emulsion (*91*), and a mixture of 65% silicate, 15% glycerine, 15% paraffin wax, and 5% oleic acid (*44*).

The paper may be coated to stiffen the sheet with a siliceous silicate solution containing glycerine or a fatty oil, perhaps with subsequent addition of acids (*9*), or simply with a substantial coat of 40° Bé silicate at ordinary temperatures (*1*). Low-cost, general-purpose coatings may contain clays and starches suspended in sodium silicate which are precipitated with alum (*97*). A more complicated mixture includes 50% silicate, 25% starch, 15% glycerine, and 10% soap which after coating is precipitated by passage through a second bath containing alum, or acidic materials (*25*). Lofgren states that a washable wallpaper can be produced by coating with a mixture of pigments, fatty acid soaps, oil-seed flours, and silicate (*56*). Colored paper is obtained by coating with 0.5 to 2% dye dispersed in a 15 to 35° Bé solution of a siliceous silicate containing 2 to 5% gum ghatti (*7*).

Mitchell has patented the treatment of silicated coated paperboard with citric or alcoholic phosphoric acids to increase their ability to inhibit rancidity of baking products (*63*). A silicate-impregnated cigarette wrapper is said to prevent flaking of the cigarette paper when burned and to lessen the fire hazard from discarded cigarettes (*57*). Another patent claims that impregnation of a zone of the cigarette wrapper with silicate, glycerol, starch, and talc prevents smoldering of discarded cigarettes (*79*). Marriott's patent discloses the preparation of a facsimile reproduction medium by applying to a carbon paper a sodium silicate coating containing 0.5 to 1% glycerin which forms bubbles on being heated with an electric stylus (*59*).

Sweetland has prepared a moisture-resistant filter which neutralizes acidity in an oil by impregnating paper with sodium silicate followed by drying for 2 hours at 225 to 325°F. to insolubilize the silicate. An

acid or acid-reacting salt may also be used (*89*). Novak and others produce wallboard by allowing silicate coated papers to react with gypsum, plaster, magnesium oxide or chloride, or asbestos (*20, 66, 78*). Another Novak patent (*67*) claims that coating news, groundwood, straw, or other low-grade fibers with 10 to 15% sodium silicate produces a board suitable for use in tubes which have a crushing strength greater than tubes made from kraft, chestnut, or tan bark board. Ohl suggests the use of potassium silicates in coatings to minimize a possible effluorescence which may occur under adverse conditions with the sodium salts (*69*). Potassium silicates are more expensive than sodium but under some conditions at least are cheaper than paraffin or other organic coatings Gessler and Bernardi coat porous paper for high-finish printing with a siliceous silicate so concentrated that it solidifies on the loss of only a small amount of water (*38*).

One of the difficulties encountered in coating some papers is that the alkali in even the more siliceous silicates caused staining. Stericker has recently solved this problem by coating such papers with a 10 to 55° Bé, 1.6 to 4.0 ratio silicate solution containing 0.25 to 5.0% hydrogen peroxide with possibly a small amount of pyrophosphate and magnesium salt as a stabilizing agent (*84*). This surface bleaching not only decreases normal silicate discoloration giving a paper of brightness higher than the sheet or board coated with alkaline silicate alone but may actually give brightnesses higher than those of the uncoated sheet.

Recent patents have shown that the wet and dry strengths of paper may be greatly increased by coating with silicate partially or completely neutralized with an acidic material such as sulphuric acid (*13, 47*). Data obtained by Wexler (*47*) on a filter paper impregnated with varying amounts of a 3.63 ratio sodium silicate (17.5% SiO_2), neutralized with 18.6% sulphuric acid and 0.32% phosphoric acid to a pH of 2.6 are summarized in Table II. The effects of the silica sol on wet strengths, even after 24 hours soaking, are particularly noteworthy.

Table II. Wet and Dry Strengths of Silica Sol Impregnated Paper (*47*)

Concentration, % SiO_2	*Bursting strength of paper, p.s.i.*		
	Dry	*Wet*	*Wet (after 24 hr. soaking)*
0	10	0	0
1.45	22	6	4
1.62	22	6	4
4	23	11	5.5
5	26	15	6
6	27.5	17.5	7
8	30.5	19	7.5
9	32.8	20.5	8
9.65	35	21.5	8
10.2	35	22	8.5

Eldridge showed by both laboratory and plant tests that using silicate to dissolve casein instead of other alkalies decreased the amount of protein needed to produce a good paper coating from 16 to about 13 pounds (*32*). This results in substantial savings under usual conditions. An increase in water resistance due to the silicate was also noted. The use of sodium metasilicate in place of the more siliceous products gives a thinner casein solution which penetrates a sized surface more rapidly and remains liquid for a longer time but markedly decreases water resistance.

DEINKING

Probably the earliest reference to the use of sodium silicates in deinking paper is the 1894 German patent of Horst claiming the removal of printing ink from waste paper by a mixture of "water glass" and carbon disulphide or paraffin oil (*45*). Henkel and Gessler described in 1911 a deinking process using sodium peroxide and a soluble silicate which was converted during the treatment to colloidal silica. Jespersen patented in 1922 the use of 0.5 to 1% sodium silicate, sometimes after partial reaction with lime, to remove printer's ink containing a mineral oil vehicle (*48*). Three years later Stutzke disclosed a deinking mixture of sodium silicate and sodium bicarbonate which liberated soluble silica (*86*). The use of sodium rosinate with silicates for this purpose was disclosed twenty-three years ago (*95*).

Snyder and Maclaren's 1933 patent claims that better deinking is obtained if the waste paper is first treated with a solvent for the linseed oil varnish in the ink (such as benzene, carbon tetrachloride, or ethylene dichloride) and then mixed with sodium metasilicate, perhaps with the addition of a wetting agent (*83*). The addition of a fatty alcohol or acid is also reported helpful (*82, 83*). Fisher recommends deinking at a consistency of 11 to 25% with a mixture of mineral or paraffin oil and silicate (*34*). Darling has patented the deinking of waste paper in a sodium metasilicate-hydroxide solution having a pH between 9.0 and 12.6 followed by the addition of a soap or sulphonated petroleum oil and, if the paper contains no fillers, moderate amounts of finely divided gypsum or bentonite (*27*). A patent issued to Lewis discloses deinking with 5 parts "water glass," 2 parts sodium hydroxide, and 1 part of a mixture containing 32.5% sodium carbonate, 44.9% water, 21.9% soap, and 0.7% peroxide (*55*).

Briggs and Rhodes found that sodium silicates were somewhat less effective in deinking paper than sodium oleate or a suspension of fullers earth in 0.02 *N* sodium hydroxide (which contains some sodium silicate) but were equally as effective as sodium resinate (*12*). Sodium silicates gave deinked pulp of higher brightness than sodium hydroxide, carbonate, borax, gum arabic, and a variety of other materials. Comparison of 2.0, 3.2, and 3.9 ratio sodium silicates did not show a marked superiority of any one.

Because of their better detergent action silicates remove ink and dirt from waste papers more efficiently and give a whiter, brighter pulp than caustic soda or soda ash. The silicates emulsify and suspend ink and dirts, as well as neutralizing or saponifying some types of inks. This ability to remove ink and dirt by loosening the bond between them and the paper, and emulsifying or suspending the loosened material accounts at least partially for the improved color obtained. When caustic soda is used the ink is uniformly distributed throughout the pulp giving it a gray or bluish cast. Another advantage of the silicates is that the deinking can be accomplished efficiently at lower pH's than

with caustic soda. This is of particular importance in deinking the large amount of papers now containing groundwood because such papers become yellow at high pH's in strongly alkaline solutions. The addition of a wetting agent, such as a rosin soap, with the silicate is helpful unless the papers to be deinked are heavily sized with rosin.

All of the silicates are used in deinking but the more alkaline products are preferred. Caustic soda is used with the siliceous silicates; the amount should not exceed 3%, especially with groundwood stock. The amount of silicate and wetting agent to give optimum results varies with the type of waste paper, and decreases with increase in the consistency of the pulp during deinking. At 20% consistency fairly good waste paper may be deinked satisfactorily with 2 % sodium metasilicate pentahydrate (based on the weight of the air-dry pulp) and 0.2% rosin soap, although more is required for more difficult stocks. At 5% consistency as much as 8 or 9% of the metasilicate and 0.8% rosin size may be needed for the same type of paper.

In one mill a combination of 7.5% caustic soda and 2.5% soda ash was replaced with 2.5% sodium metasilicate pentahydrate, 2.5% caustic soda, and a little pine oil, with a decided improvement in the finished paper. Replacing 1.5% caustic soda and 0.35% of a commercial detergent with 1.5% sodium metasilicate pentahydrate and about 0.15% rosin soap gave excellent results at a decreased cost. One mill deinks a high grade of waste book and newprint in a hydropulper containing 3% of the 42°, 3.2 ratio silicate and 1.5% caustic soda at a temperature of 150 to 170°F. for 45 minutes.

Recently paper mills have been using peroxides in their deinking process to give a combination of ink and dirt removal with bleaching. The silicate used in this process with the peroxide is the 58.5°, 1.6 ratio product since it is less alkaline and stabilizes the peroxide more efficiently than the metasilicate. Using silicate instead of caustic soda with peroxide has increased the brightness of deinked pulp containing groundwood by as much as 5 points in actual mill tests and slightly decreased the amount of peroxide needed. Generally 3 to 6% of the 58.5°, 1.6 ratio silicate, 0.5 to 2% caustic soda, and 1 to 3% hydrogen peroxide based on the weight of waste paper stock are used. If sodium peroxide is employed no extra caustic soda need be added. One mill uses 6% of the 1.6 ratio silicate and 1.5% sodium peroxide in a horizontal cooker at 160°F. for 60 to 90 minutes and produces a coated book paper from the deinked stock. Another uses 5% of the 1.6 ratio silicate, 0.5% caustic soda, and 1.5% hydrogen peroxide for deinking waste paper and newsprint in a hydropulper at 120°F. for 25 to 35 minutes.

RAG AND STRAW COOKING

The detergent properties and alkalinity of the more alkaline silicates are also responsible for their use in rag and straw cooking. Some mills wash rags before cooking them by flushing with warm or hot water followed by a bath of hot water containing about 2 pounds metasilicate pentahydrate per 100 pounds of rags and a small amount of fatty acid or rosin soap. After 20 minutes washing, the rags are thoroughly rinsed.

Replacing $^1/_2$ to $^1/_5$ of the sodium hydroxide used in cooking rags with sodium metasilicate pentahydrate has resulted in whiter, cleaner, stronger rags which are more readily bleached. The best formula varies with conditions and type of rags; 10% sodium hydroxide and 5% metasilicate pentahydrate on the weight of the rags have been used for cooking quilts and rags; a lesser amount such as 9% caustic soda and 3% metasilicate is sufficient for batting and linters. One mill obtains excellent results by cooking 4000 pounds of dirty rags for 10 hours in 2200 gallons of water with 320 pound of caustic soda, 80 pounds sodium metasilicate pentahydrate, and 25 pounds of rosin size. Following the cook, the stock is drained and washed free of alkali if it is to remain in the bins. Stock going directly to the washing beaters need not be drained as the presence of the metasilicate aids washing.

Cooking straw in silicate instead of the usual lime or caustic soda-soda ash mixtures results in an increased yield of stronger, cleaner, more workable fiber. Precipitation of the silicate cooking liquor in the beater with alum gives a well-sized sheet of improved formation and greater strength per unit weight (*28*). Addition of silicate to the cooking liquors containing only sodium salts decreases the time needed to obtain a satisfactory cook. For example, 1000 kg. of straw are satisfactorily cooked in 2000 liters of solution containing 85 kg. sodium sulphite, 35 kg. sodium silicate, 20 kg. of sodium hydroxide, and 5 kg. of sodium carbonate at 160°C. for 4 hours. If the silicate was not present an additional 35 kg. of caustic soda and 5.5 or 6 hours were necessary to get a similar result (*11*). Good results have been obtained by cooking straw in a mixture of 100 pounds metasilicate pentahydrate and 150 pounds sodium hydroxide with the addition of some sulphite.

BLEACHING

Peroxides

Sodium silicates and peroxides have been proposed as bleaching compositions for more than fifty years but only about eight years ago was a commercially practical method developed for bleaching pulp, particularly groundwood. The history and present status of peroxide bleaching of groundwood were summarized recently by Reichert and Pete (*77*). Briefly, the process consists in mixing the groundwood suspension with 5% of the 42°, 3.2 ratio sodium silicate, 1 to 2% sodium peroxide, 0.025 magnesium sulphate, and 1% 66° Bé sulphuric acid. These amounts are based upon the air-dry weight of the pulp; their concentration varies with the consistency.

One of the functions of the silicate is to stabilize the peroxide and protect it from decomposition. A 1 volume hydrogen peroxide solution adjusted to pH 10 with sodium hydroxide was 50% decomposed in approximately 15 minutes at a temperature of 180°F. When 7.2 grams of sodium silicate per liter were present, 3 hours were required for 50% decomposition; the further addition of 27 p.p.m. magnesium ion as magnesium sulphate increased this to 45 hours (*75*). Metal ions, such as iron, copper,

titanium, and manganese, catalyze peroxide decomposition. Part of the action of the silicate is to combine with these and thus make them ineffective as catalysts. Siliceous silicates stabilize peroxide in the absence of metal catalysts so that another mechanism must also be involved. Probably some sort of combination between silicate and peroxide occurs. Several claims have been made in the literature for the isolation of such compounds.

Sodium silicates also function in the bleach bath as a detergent and penetrant and contribute to the brightness of the pulp. A groundwood pulp bleached with 3% sodium peroxide at 100°F. had a brightness of 68% when 10% sodium silicate was used but only 62.5% when 2% silicate was used (*76*). In addition, the silicate buffers the bleaching solution in the desired optimum range of pH 10 to 11. A further purpose is to inhibit corrosion, probably by forming an invisible metal silicate coating at the surface of the metal equipment.

Hypochlorite

That sodium silicates increase the efficiency of hypochlorite bleaching was established in laboratory studies by Carter in 1924 (*15*). The silicates did not greatly effect the stability of either sodium or calcium hypochlorite solutions in contact with air or inert material. However, in the presence of sulphite pulps, addition of silicate not only gave a better color pulp but also decreased the amount of calcium hypochlorite used. Similar laboratory tests with sodium hypochlorite showed little effect due to silicate although subsequent mill tests showed decided improvement due to silicate. In many cases the color of the pulp bleached by calcium hypochlorite and silicate was better than could be obtained with much larger amounts of the hypochlorite alone. Addition of silicate to the bleach bath decreased the loss in tensile strength of cotton fabric during bleaching and would presumably behave similarly with paper pulp. The silicate treatment increased the ash content of the pulps. Optimum results were obtained with 1% of the metasilicate or 1.6 ratio silicate on the weight of the air-dry pulp; these were more effective than the siliceous products in tests with sulphite pulps. The calcium silicate precipitate was not responsible for the effect of the sodium silicate in improving color.

Experiences on a full plant scale during the past ten years have shown that whiter, brighter pulps are obtained with less bleach when sodium silicates are used than with calcium or sodium hypochlorite alone. The effect of the silicates is not due entirely to their alkalinity; sodium hydroxide does not give the same result even at comparable pH's whereas sodium carbonate seems to be detrimental. A paper company using 481 pounds of chlorine to brighten 9000 pounds of sulphate pulp in 30 minutes to a brightness of 32 was able to obtain the same brightness in approximately 13 minutes with 427 pounds of bleach when silicate was used. In a series of mill runs on sulphate pulp the brightnesses obtained were 61.0 with silicate and 51.7 without. Mill tests with single stage bleaching of sulphite pulp show that the amount of chlorine can be reduced by 20 to 35% and an equally good colored pulp obtained if 1% of metasilicate pentahydrate or the 58.5°, 1.6 ratio silicate is added. One mill used $^3/_8$% metasilicate pentahydrate on the weight of the air-dry pulp and reduced the chlorine added by 15% to give the same whiteness of pulp at a net saving of $0.56 per ton of pulp.

Bleaching procedures vary widely in each paper mill and some experimentation is necessary to find the best conditions for the use of silicates. Such tests should be carried out under mill conditions; the usual laboratory bleaching tests do not always show effects obtained in practical experience. Usually 1% sodium metasilicate pentahydrate or the 58.5°, 1.6 ratio is used with sulphite or sulphate pulps. For soda pulps 2% of the 38.5°, 3.7 ratio silicate gives better results. Recent investigations on groundwood bleaching with hypochlorites have shown that substitution of sodium silicate for part of the 3 to 6% lime required for bleaching some pulps further improves the brightness up to 5 points (*51*). Brallier and Nowicke claim that groundwood can be bleached in about one hour at approximately 50°C. with calcium hypochlorite in the presence of 20 mg. sodium hydroxide and 60 mg. sodium silicate per gram of pulp (*10*). Silicate would be expected to produce similar effects in all types of hypochlorite bleaching, but complete methods have not been worked out for bleaching other materials.

The effect of sodium silicates in hypochlorite bleaching involves their dispersing and penetrating action so that more rapid and intimate contact between fibers and pulp is obtained. It also involves the detergent action of the silicates in removing dirt and other noncellulosic constituents from the fibers, as well as oxidation and chlorination products which inhibit further bleaching. Another action of the silicate may be to buffer the bleaching bath at the optimum pH for most effective bleaching and to exert a protective action on the fibers thus increasing their strength. The increased yields of pulp result from retention of the precipitate of hydrous calcium silicates and probably also from less attack on the pulp by the bleach. Shives are swollen thus enabling removal of lignious material.

ACTIVATED SILICA SOLS

Activated silica sols were developed as a coagulant or coagulant aid for the treatment of raw water a little over ten years ago. Since then they have been used by paper mills not only for this purpose but also to improve filler and fiber retention on the wire of the paper machine and in savealls as well as for the treatment of all types of mill wastes. Activated silica sols are prepared by diluting the 42°, 3.2 ratio silicate with water, adding an acid or ammonium sulphate, allowing the mixture to age for a short time, and then further diluting to stabilize the solution (*62*).

Significantly two of the earliest industrial users of activated silica sols were paper mills. Noreus of the Northwest Paper Co. reported in 1944 that the use of activated silica sols made it possible to obtain from Minnesota's highly colored St. Louis River a filtered water of lower color and turbidity at a higher rate from a modern upflow unit (*65*). The activated silica was added after the alum which allowed it to react with the negatively charged color and other impurities before forming a large dense rapidly settling floc. Klinger's tests on Wisconsin waters showed that acti-

vated silica produced more effective coagulation, particularly in cold weather, larger and denser flocs, a saving of alkali or alum during periods of easy coagulation, and longer filter runs (*54*). Use of activated silica broadened the pH range of effective coagulation and made it possible to treat satisfactorily a water of somewhat higher pH. In addition it allowed longer filter runs, gave better reduction of color than alum alone, produced a filtered water of higher quality, prevented "after precipitation" in the clear well, and reduced the amount of silica in the treated water. Similar experiences have been reported elsewhere. One large paper mill reports that activated silica is the only coagulant it has found that will aid coagulation when waste liquor from a sulphite mill is present in the raw water.

The addition of 10 to 20 p.p.m. of activated silica sols to the pulp stock at a point between the jordans and the headbox of the paper machine produces increased retention of filler and fiber on the wire and better more uniform formation of the paper. Sufficient alum, calcium carbonate, or other suitable material are needed to react with the activated silica. Ordinarily a pH of 5.0 indicates that sufficient alum is already present in the stock from the beaters; sometimes it is desirable to add a small additional amount of alum or other coagulant. Methods have been developed for using activated silica on calcium carbonate filled sheets without difficulty due to gassing. Increased retention of filler and fiber is demonstrated initially by an immediate increase in the basis weight of the paper and also by a reduction, usually around 50%, in the solids content of the waste water coming from the paper machine. In one case retention of clay increased from 58.6 to 79.8%. The addition of 10 to 20 p.p.m. activated silica produces no observable change in the freeness of the stock. However by increasing the amount to 75 to 100 p.p.m., the pulp stock can be "slowed down" when desired. The cost of the activated silica is about one-half that of the glue frequently used for this purpose. Since mill conditions and paper stocks vary widely, some experimentation is necessary to obtain optimum conditions for any activated silica sol application in a particular case.

Similarly, activated silica sols aid the recovery of fiber and fillers in settling, mechanical, vacuum, or flotation-type savealls by coagulating them. In this application 10 to 15 p.p.m. activated silica are used. In many cases the solids content of white waters originally containing 10 to 20 pounds per 1000 gallons was reduced to 0.5 pound per 1000 gallons or even less.

Increased emphasis on stream pollution control during the past few years has created interest in economical methods for treating paper mill wastes. Here again activated silica sols have been useful but optimum dosages and conditions need to be developed for each case. In one case a deinking waste which could not be satisfactorily treated by any reasonable amount of alum or lime was coagulated by 4 grains per gallon of lime and 1.1 grains per gallon of activated silica.

MISCELLANEOUS

Sodium silicates may also be used in compositions for improving the stiffness and fire resistance of molded paper products such as plates. Herting, for example, treats a product previously impregnated with soluble aluminum and titanium salts with a siliceous sodium silicate containing borax and sodium sulphate and dries at elevated temperatures to produce a heat-resisting product (*43*). Further treatment with a weak acid prevents staining by fruit juices. Clapp impregnates an asbestos-cellulose paper containing lime with a diluted sodium silicate, dries to 20 to 30% water, and then sprinkles the molded product with china clay and silex to give a white enamellike surface (*22*). The reaction of pulp containing kieselguhr, or heavy metal oxides, with silicates at 200 to 300°F. produces a water-resistant article. Such products may be covered with graphite and then coated with metal by electrodeposition (*22*). Molds for making these products are cleaned with sodium sesquisilicate and a synthetic detergent.

A silicate cement long used in lining sulphite digesters consists of 2 parts of 20-mesh ground quartz, 1 part Portland cement and sufficient 52°, 2.4 ratio silicate to give a good working consistency. This is mixed in small batches since it sets almost immediately. Between the two brick linings is put a packing of similar cement, with 4 parts of quartz to 1 of cement. Concrete floors and tanks, are made harder, dustproof, and more acid resistant by treatment with three or four coats of the 42°, 3.2 ratio silicate diluted with about four parts of water. A somewhat better method is to dilute 1 part of the silicate with 4 parts of water for the first coat, 3 parts for the second coat and 2 parts for the third. The third coat is absorbed slowly but almost completely and any excess can be washed off. Concretes which are still porous can be further treated with a 1 to 2 dilution.

Some mills find that wire corrosion is lessened, forming reduced, or better formation of the paper obtained if the pH of the paper stock is raised from 4.5 to 5.0 in the headbox of the paper machine by the addition of a 10% solution of sodium metasilicate pentahydrate. A slight increase in fiber retention was also noted. One mill has added a 5% solution of the 42°, 3.2 ratio silicate in the headbox for these purposes although better fiber retention is obtained with activated silica sols. Another mill adds a very dilute solution of the 42°, 3.2 ratio silicate to the wire of their paper machine on the return circuit in order to minimize the highly corrosive effects of a chemically treated pulp. Formerly the wires lasted only 4 to 5 days but the silicate treatment has extended their life to 29 to 30 days. Silicates are regularly used to prevent corrosion in water pipes, especially of hot water systems.

One paper mill has found that applying the 42°, 3.2 ratio silicate to the lap of the paper machine felts at the time they are replaced, followed by air drying provides a very slowly dissolving source of alkali which prevents rotting of fabrics at this point when subjected to acid conditions. A German patent (*72*) claims that the felt may be made resistant to heat, acids, and rot by coating with sodium silicate followed by treatment with a magnesium chloride solution. Paper mill felts are washed in a solution of 0.5 to 10 pounds of sodium metasilicate and an equal weight of soap in 50 gallons of water, usually at a temperature around 100°F.

The use of a 2.0 ratio silicate to cause the formation of a bulky, nonadherent floc instead of a hard dense crystalline precipitate which adheres to the walls of steam boilers has been standard practice for many years. This makes it possible to remove impurities as mud by blowing off the boiler. Jones and Weitzel have recently reemphasized the value of this treatment (*49*). The industrial use of the more soluble potassium silicates for boiler water treatment is a development of the past few years.

Silicates have been used for many years to increase the fluidity of clay mixes. This makes it possible to handle them at solids contents as high as two fold greater than without the silicate. The optimum amount to use depends on the type of material to be deflocculated but is usually between 0.1 to 1% on the weight of the clay. Dickerman has recently described the conversion of a clay filter cake containing less than 67% solids to one containing 70% solids by the addition of a dispersing agent such as metasilicate and a relatively dry clay (*30*).

The adhesive properties of sodium silicates are used in the paper mill for roll capping, label pasting, making splices in supercalendering, and carton sealing. The silicate recommended for capping rolls is the 47°, 2.9 ratio product. It may be diluted 10 to 20% by volume with water or if headers are used by as much at 50%.

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UNITED STATES PATENTS ON PAPERMAKING

Second Quarter, 1949 — *Compiled by CLARENCE J. WEST*

The following list of patents has been compiled from the current numbers of the Official Gazette of the United States Patent Office. Because, as a rule, only one claim is published in the Gazette, is it not claimed that the list is complete; also, it is possible that the list may contain some patents that do not apply specifically to the pulp and paper manufacture.

Copies of any of the following patents can be obtained from the United States Patent Office, Washington 25, D. C., by sending twenty-five cents for each patent desired.

April 5, 1949

R 23,096. Moistureproof package. Charles D. Mullinix, Los Angeles, Calif. Filed Nov. 22, 1944. 12 claims. (Cl. 229-87.) This is a reissue of U. S. patent 2,335,019 (Nov. 23, 1943) and relates to a package for butter and other greasy foods. The package is made of laminated paper blanks having at least two layers and bonded by paraffin and latex.

2,466,172. Method of preparing an adhesive from cereal flour. Carl C. Kesler and William L. Hicks, assignors to Penick & Ford, Ltd., Incorporated, Cedar Rapids, Iowa. Filed May 10, 1945. 6 claims. (Cl. 106-210.) The cereal flour in water is adjusted to a pH of 9–10 with alkali, heated at about 130°F. to inactivate the naturally occurring enzymes, further heated at 170–210°F. to cook the starch, and adjusted to a pH of 5–7.

2,466,290. Method of digesting pulp by the alkaline process. Sidney D. Wells, assignor to The Institute of Paper Chemistry, Appleton, Wis. Filed March 15, 1944. 1 claim. (Cl. 92-13.)

Clarence J. West, Chairman, Committee on Bibliography, TAPPI.

A method is provided for regulating the admission of active chemical into the batch of circulating liquor in accordance with the condition or chemical activity of the circulating liquor at the time the chemical is added.

2,466,341. Container forming machine. John G. Vergobbi, assignor to Pneumatic Scale Corporation, Limited, Quincy, Mass. Filed March 27, 1947. 4 claims. (Cl. 93-44.1.) An apparatus is described for forming a rectangular container having a face-to-face or fin-type seam.

2,466,579. Molded pulp carton. John W. Cox, assignor to Shellmar Products Corporation, Chicago, Ill. Filed Sept. 20, 1943. 2 claims. (Cl. 229-28.) Cellular egg cartons of the two-by-six type are molded of paper pulp.

2,466,599. Foldable display panel with collapsible support. James L. Larkin, assignor to Forbes Lithographic Manufacturing Company, Chelsea, Mass. Filed Jan. 11, 1944. 10 claims. (Cl. 40-124.1.) The display consists of a foldable panel and a collapsible support.

2,466,633. Method of bleaching cellulosic pulp. George J. Brabender, John W. Bard, and James M. Daily, assignors to James M. Daily, Portland, Oreg., Francis L. Daily, Chicago, Ill., and Joseph F. Ryan, McAllen, Tex. Filed May 26, 1948. 7 claims. (Cl. 8-104.) Pulp containing from 45 to 75% moisture at a pH of 5 to 6 is treated with air containing 0.5% ozone at room temperature.

2,466,649. Dissolving apparatus for the preparation of cellulose solutions. Arie van Halewijn, assignor to American Enka Corporation, Enka, N. C. Filed Dec. 6, 1946. 1 claim. (Cl. 23-267.) This is an improvement over U. S. patent 2,289,085 (July 7, 1942) and relates to a method of dissolving cellulose in a salt solution such as a zincate or stannate.

April 12, 1949

2,466,671. Froth flotation on nonmetallic ores with black liquor soap in acid circuit. Elmer W. Gieseke, assignor to American Cyanamid Company, New York, N. Y. Filed Sept. 22, 1945. 2 claims. (Cl. 209-166.) In the froth flotation of phosphate ores, black liquor (tall oil) soap is used as a collector.

2,466,672. Coating composition containing a fatty acid ester as a gel stabilizing agent. Emile E. Habib and David G. Greenlie, assignors to Dewey and Almy Chemical Company, North Cambridge, Mass. Filed May 20, 1947. 7 claims. (Cl. 260-23.5.) Gels of metal soaps in paraffin wax are stabilized against separation on heating by the inclusion of fatty acid esters of anhydrohexahydric alcohols. They are used to vaporproof paperboard.

2,466,718. Coating apparatus. Robert Lobstein, assignor of one half to Samuel R. Hunter, Chicago, Ill. Filed March 21, 1946. 5 claims. (Cl. 91-48.) A method and apparatus are described for coating paper and other material by applying coating liquor to one or both surfaces during the process of its manufacture before it is completely dry.

2,466,734. Apparatus for controlling the coating applied to an object. Thomas E. Piazze, assignor to Shellmar Products Corporation, Mount Vernon, Ohio. Filed May 4, 1945. 2 claims. (Cl. 91-53.) An apparatus is described for regulating and controlling the amount of viscous coating solution applied to a moving object.

2,466,823. Paper bag tube severing machine. George W. Poppe, assignor to Equitable Paper Bag Co., Inc., Long Island City, N. Y. Filed Oct. 11, 1946. 7 claims. (Cl 164-84.5.)

2,466,966. Method for making decorated laminated articles with contoured surfaces. Alvin W. Prance, and Fred Lyijynen, assignors to Briggs Manufacturing Company, Detroit, Mich. Filed July 7, 1944. 5 claims. (Cl. 154-110.) A substantially planar sheet carrying a printed design, impregnated with a liquid resin varnish, and superimposed upon a laminated foundation board.

2,466,987. Froth flotation of iron ores. Earl C. Herkenhoff, assignor to American Cyanamid Company, New York, N. Y. Filed June 10, 1944. 4 claims. (Cl. 209-166.) Tall oil is used as an ionic-type promoter in the froth flotation of iron ores.

2,467,016. Fibrous container for oil and other liquids. Charles K. Dunlap, Hartsville, S. C., assignor to Sonoco Products Company. Filed Feb. 16, 1944. 4 claims. (Cl. 229-3.5.) A container is lined throughout with glassine paper which is bonded to the tube by an oilproof adhesive.

2,467,082. Method of producing chalk Louis C. Fleck, assignor to Paper Patents Company, Neenah, Wis. Filed June 11, 1948, 5 claims. (Cl. 23-66.) An aqueous calcium hydroxide slurry is carbonated in the presence of sugar beet residue extract.

2,467,182. Method of making fiber containers with metallic closures. Robert Beattie, assignor to Tide Water Associated Oil Company, Bayonne, N. J. Filed April 1, 1946. 6 claims. (Cl. 113-120.) Containers for oil or other liquids have end closures of relatively thin-gage metal.

2,467,245. Polymerization of ethylene. Gerald M. Whitman and Samuel L. Scott, assignors to E. I. du Pont de Nemours & Company, Wilmington, Del. Filed Feb. 5, 1946. 3 claims. (Cl. 260-94.9.) The polymerization product from ethylene is suitable as a waterproofing agent for paper.

April 19, 1949

2,467,502. Cleaning apparatus. Gilbert J. Scofield, Loudonville, N. Y. Filed May 23, 1945. 1 claim. (Cl. 92-50.) An apparatus for cleaning Fourdrinier wires.

2,467,540. Manufacture of asbestos sheet material. Marion F. Smith and Harold W. Greider, assignors to The Philip Carey Manufacturing Company, Cincinnati, Ohio. Filed Jan. 15, 1945. 1 claim. (Cl. 117-126.) The asbestos in sheet form is treated with 10–30% aqueous hydrofluoric acid and dried at 200–300°F.

2,467,556. Combination papermaking machine. Burton E. James and Edward D. Beachler, assignors to Beloit Iron Works, Beloit, Wis. Filed May 29, 1944. 12 claims. (Cl. 92-69.) The patent covers a papermaking machine adapted to produce creped paper or flat paper with no crepe.

2,467,702. Flap holding means for cartons. Sidney K. Smart, assignor to Shinners Packaging Incorporated, Springfield, Mass. Filed June 3, 1948. 1 claim. (Cl. 229-45.) The end closure of a carton is provided with a hole in the locking flap.

2,467,728. Sawing apparatus. George H. Burt, assignor to The Celotex Corporation, Chicago, Ill. Filed Nov. 14, 1946. 6 claims. (Cl. 125-13.) A sawing apparatus is described for forming tilelike units.

2,467,829. Paper machine clutch drive. Lloyd Hornbostel, assignor to Beloit Iron Works, Beloit, Wis. Filed March 22, 1943. 7 claims. (Cl. 192-87.) The invention relates to fluid pressure-controlled clutch drives for starting sections of a papermaking machine.

2,467,830. Fluid pressure operated device for use with

clutches. Lloyd Hornbostel, assignor to Beloit Iron Works, Beloit, Wis. Filed April 26, 1945. 1 claim. (Cl. 137-157.) A split diaphragm is used.

2,467,875. Package and packaging material therefor. David B. Andrews, assignor to Marathon Corporation, Rothschild, Wis. Filed Jan. 7, 1947. 6 claims. (Cl. 99-178.) A cheese wrapper consists of paper, glassine, and the like with a tearing element embedded in the coating.

2,467,878. Pulpstone. Hugo W. H. Beth, assignor to Norton Company, Worcester, Mass. Filed Aug. 1, 1946. 2 claims. (Cl. 51-206.4.) The construction of a pulpstone is claimed.

2,467,879. Bagmaking machine. Clyde K. Billeb, assignor to Milprint, Inc., Milwaukee, Wis. Filed May 17, 1945. 4 claims. (Cl. 154-42.) A machine for forming bags from a rapidly advancing ribbon of paper or the like.

2,467,930. Paper container structure and method of forming same. John Coyle, assignor to Continental Can Company, Inc., New York, N. Y. Filed Jan. 14, 1944. 5 claims. (Cl. 229-5.5.) The container has a paneled or polygonal main body portion and cylindriform end portions in which the end closures are adhesively attached.

2,467,973. Blank aligning mechanism. Irving J. Gannon and James R. Harvey, assignors to The Ohio Boxboard Company, Rittman, Ohio. Filed Oct. 12, 1945. 6 claims. (Cl. 93-58.) Guide means are provided for edge alignment of sheets from the cutting machine.

April 26, 1949

R 23,102. Waterproof explosive cartridge. Arthur W. Baker, assignor to Hercules Powder Company, Wilmington, Del. Filed Aug. 21, 1947. 5 claims. (Cl. 102-24.) This is a reissue of U. S. patent 2,408,189 (Sept. 24, 1946) and relates to a cartridge formed of laminated asphalt paper.

2,468,086. Process of rendering anionic coating materials adherent to anionic bases. Henry H. Latham and Joseph R. Morton, assignors to Morton Chemical Company, Greensboro, N. C. Filed June 21, 1948. 12 claims. (Cl. 117-56.) In the coating of paper and like material with natural and synthetic rubbers, resins, and the like, the base material is coated or impregnated with a cationic active agent.

2,468,123. Folding carton. Frank C. Shina, assignor to United Board & Carton Corporation, New York, N. Y. Filed Sept. 18, 1946. 2 claims. (Cl. 229-37.) An end closure is designed for a hexagonal container.

2,468,207. Treatment of starch. Ralph W. Kerr, assignor to Corn Products Refining Company, New York, N. Y. Filed July 18, 1945. 7 claims. (Cl. 127-32.) Starch is gelatinized in the presence of 0.5–10% of sodium stannate; the potassium salt or a mixture of the two can be used.

2,468,306. One-piece paper container. Jesse Norden, Woodmere, N. Y. Filed Dec. 18, 1946. 4 claims. (Cl. 229-3.5.) The construction of paper containers (especially milk bottles) is described.

2,468,443. Remoistening adhesive composition. Ferdinand W. Humphner, assignor to Mid-States Gummer Paper Co., Chicago, Ill. Filed Aug. 14, 1948. 3 claims. (Cl. 106-128.) An adhesive for gummed tape contains starch acetate and bone glue in water.

2,468,534. Tough, flexible, polyamide resin-hydrocarbon resin composition. David W. Young and William J. Sparks, assignors to Standard Oil Development Co., Linden, N. J. Filed Nov. 23, 1944. 5 claims. (Cl. 260-23.) A polyamide resin (40–99%) and a styrene-isobutylene copolymer (1–60%) is useful as a paper coating.

2,468,543. Box. John W. Chalmers, assignor to Molins Machine Company, Limited, London, England. Filed Dec. 19, 1945. 2 claims. (Cl. 229-16.) The back of the box is provided with two slits which commence at opposite ends of the hinge and extends toward the bottom of the box.

2,468,595. Machine for slitting and widening boards. Armin Elmendorf, Winnetka, Ill. Filed Sept. 7, 1945. 5 claims. (Cl. 144-2.)

2,468,657. Treatment of drilling fluids. Milton Dyke and Edward S. Self, assignors to Oil Well Chemical and Materials Company, Inc., Los Angeles, Calif. Filed April 29, 1946. 4 claims. (Cl. 252-8.5.) A water-clay base drilling fluid consists of clay and from 1 to 10% of tall oil soap.

2,468,658. Treatment of drilling fluids. Milton Dyke and Edward S. Self, Bakersfield, Calif. Filed July 21, 1947. 10 claims. (Cl. 252-8.5.) A water base drilling fluid consists of clay and from 1 to 6% of tall oil soap.

2,468,695. Method of making unit dispensing packages. George W. Wallace, Waynesboro and James W. Trew, Gettysburg, Pa. Filed Aug. 1, 1945. 2 claims. (Cl. 93-2.) A method is described for packaging apples and the like.

May 3, 1949

2,468,724. Wrinkle flexible material with rubber coating. Nathan T. Beynon, assignor to New Wrinkle, Inc., Wilmington, Del. Filed March 21, 1946. 8 claims. (Cl. 117-161.) Paper is coated with a mixture of unsaturated fatty oil and a synthetic rubber.

2,468,777. Can body making machine. John F. Peters, assignor to American Can Company, New York, N. Y. Filed Dec. 8, 1943. 7 claims. (Cl. 93-52.) In the formation of tubular fiber containers, provision is made for preheating the edge portions for applying adhesive thereto.

2,468,792. Drilling fluids and methods of using same. Cary R. Wagner and William N. Axe, assignors to Phillips Petroleum Company, Bartlesville, Okla. Filed Aug. 18, 1947. 12 claims. (Cl. 252-8.5.) Oxycellulose or a salt is used.

2,468,853. Abrasive web material. John A. Williamson, assignor to The Carborundum Company, Niagara Falls, N. Y. Filed Sept. 15, 1944. 11 claims. (Cl. 51-294.) A method of making flexible fibrous abrasive web.

2,468,876. Sanitary pad. William A. Hermanson, Boston, Mass. Filed April 30, 1945. 6 claims. (Cl. 128-290.)

2,468,922. Machine for applying labels to containers. Thomas L. Cook, San Francisco, Calif. Filed Dec. 12, 1944. 15 claims. (Cl. 216-58.)

2,468,951. Folded box. Bert H. Barter, assignor to Great Southern Box Company, Inc., New Orleans, La. Filed Sept. 1, 1945. 1 claim. (Cl. 229-34.) The box is of double thickness at the corners with sides and ends folded double along lines that define the top edges of the box to form inner and outer side and end panels.

2,469,013. Method of evaluating paper towelling or the like. John Sobota, assignor to Fort Howard Paper Company, Green Bay, Wis. Filed Jan. 19, 1948. 2 claims. (Cl. 73-159.) A method of measuring the wet strength of paper towels.

2,469,030. Paste-applying mechanism. William A. Brown, assignor to Hartford-Empire Company, Hartford, Conn. Filed Jan. 5, 1945. 10 claims. (Cl. 91-54.) A lap-end pasting mechanism for labeling machines.

2,469,049. Pencil with body of convolutely wound paper. Kay Miller, assignor to Joseph Dixon Crucible Company, Jersey City, N. J. Filed March 11, 1947. 2 claims. (Cl. 120-83.) The core of marking material is wound with a sheet of paper impregnated with a lubricant (paraffin, greases, or waxes); the successive layers are adhered by sodium silicate adhesive.

2,469,108. Wax-polyamide-pinene resin coating composition. Karl W. Fries, assignor to Rhinelander Paper Company, Rhinelander, Wis. Filed Aug. 6, 1945. 3 claims. (Cl. 260-23.) A moistureproofing coating composition.

2,469,251. Envelope. Edward R. White, New Rochelle, N. Y. Filed Dec. 21, 1945. 9 claims. (Cl. 229-82.) A paper bag is provided with a sheath at the flap end which has an entrance slot and a tongue which bridges the open end of the bag.

2,469,343. Spoon package. Edwin C. Siewert, assignor to Marathon Corporation, Rothschild, Wis. Filed March 7, 1946. 1 claim. (Cl. 229-1.5.) A means for retaining a spoon within a package of ice cream.

May 10, 1949

R 23,111. Process for producing chlorine dioxide. Torsten G. Holst, assignor to Mo Och Domsjö Aktiebolag, Ornskoldsvik, Sweden. Filed July 23, 1947. 14 claims. (Cl. 23-152.) This is a reissue of U. S. patent 2,373,830 (April 17, 1945).

2,469,497. Folding box. James F. Conway, assignor to National Folding Box Company, Incorporated, New Haven, Conn. Filed Aug. 25, 1945. 1 claim. (Cl. 229-6.) A one-piece radio carton.

2,469,535. Container. Marshall I. Williamson, assignor to National Folding Box Company, Incorporated, New Haven, Conn. Filed Oct. 26, 1944. 4 claims. (Cl. 229-37.) A container with a siftproof end closure

2,469,536. Method of making shopping bags. Franklin P. Winesett, assignor to Crown Zellerbach Corporation, San Francisco, Calif. Filed March 4, 1946. 4 claims. (Cl. 93-35.) A shopping bag with a folded top and with handles having their ends secured to and covered by the bag.

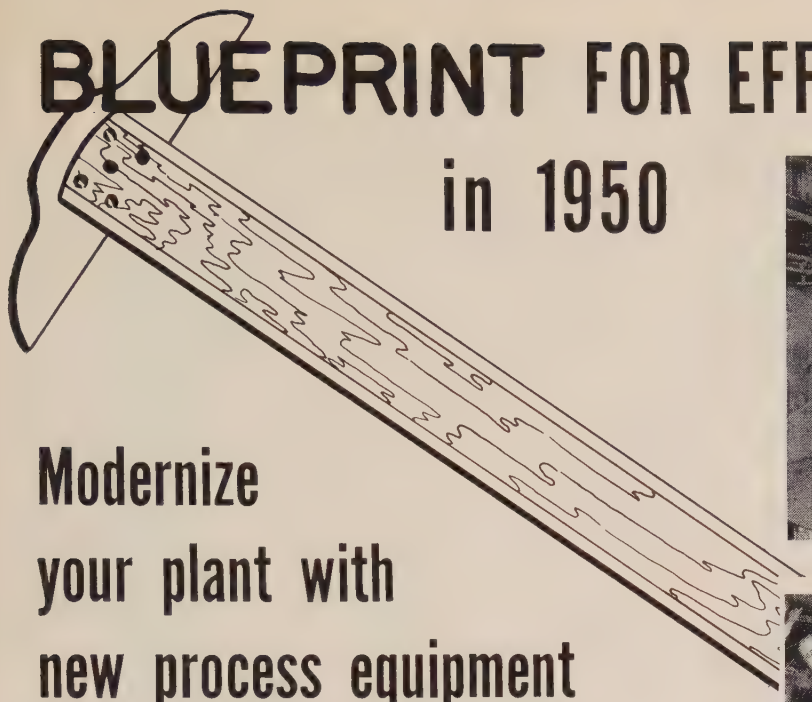
2,469,625. Method of rendering hydrophilic substance water repellent. Arthur J. Barry, assignor to The Dow Chemical Company, Midland, Mich. Filed Dec. 10, 1943. 2 claims. (Cl. 117-121.) An organosilicon compound is used.

2,469,641. Method of and machine for making unitary set-up covered boxes. Harold J. Goss, assignor to Central National Bank of Cleveland, Cleveland, Ohio. Filed Jan. 4, 1947. 16 claims. (Cl. 93-51.) A machine is described for forming a unitary box having a body provided with end walls of double thickness and concealing tabs projecting from the ends of the rear walls of the body.

2,469,853. Multisection envelope and blank for forming the same. Thomas A. Terry, assignor to C. & M. Envelope Company, New York, N. Y. Filed April 10, 1945. 1 claim. (Cl.

(continued on page 58 A)

BLUEPRINT FOR EFFICIENT OPERATION in 1950

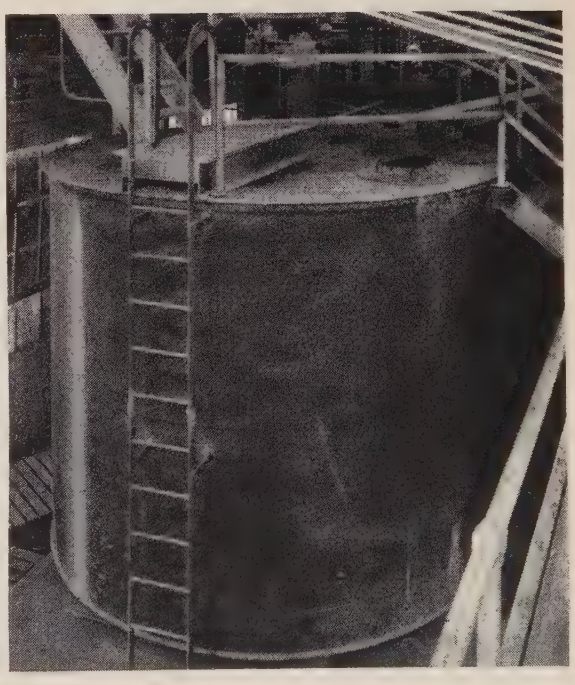


Modernize your plant with new process equipment

Wise business managers are already planning to meet the challenge of a buyer's market by installing equipment that means *more efficient operation* for 1950. For pulp and paper men, this sensible procedure requires a critical look at the various specialized containers which make up an important part of any pulp mill's production facilities. Is it really wise to "get-by" with what you have when up-to-date process equipment built by CB&I will improve your competitive position by lowering your production costs?

The accompanying illustrations show some of the equipment we recently installed for a progressive pulp producer in the South. In addition to the tanks shown, we also furnished two new stainless-steel lined digesters to replace obsolete equipment.

CB&I offers the paper industry complete facilities for designing, fabricating and erecting steel plate structures. They include digesters, diffusers, spherical acid accumulators, pulp washing tanks, flat-bottom storage tanks, and elevated water tanks. We're equipped to do x-raying and stress-relieving. We also furnish special corrosion resistant linings or build entire vessels of corrosion-resistant materials when specified. When your blueprint of operations for 1950 calls for steel plate work, ask our nearest office for quotations and complete details.



Above: Construction view of a 15-ft. diam. by 10 ft. high "smelt" tank. This tank is built of stainless steel for handling green liquor high in caustic content.

Center: Later view of the same tank. We also furnished a 17-ft. diam. by 15 ft. high smelt tank.

Bottom: A 12-ft. diam. by 10 ft. high causticizing tank. It is used for recausticizing the clarified green liquor.

CHICAGO BRIDGE & IRON COMPANY

Atlanta, 3 ... 2133 Healey Building	Detroit, 26 ... 1548 Lafayette Building	Philadelphia, 3 ... 1642—1700 Walnut Street Building
Birmingham, 1 ... 1543 North 50th Street	Havana ... 402 Abreu Building	Salt Lake City, 1 ... 1562 First Security Bank Building
Boston, 10 ... 1057—201 Devonshire Street	Houston, 2 ... 2156 National Standard Building	San Francisco, 11 ... 1238—22 Battery Street Building
Chicago, 4 ... 2140 McCormick Building	Los Angeles, 14 ... 1550 General Petroleum Building	Seattle, 1 ... 1362 Henry Building
Cleveland, 15 ... 2238 Guildhall Buildin	New York, 6 ... 3324—165 Broadway Building	Tulsa, 3 ... 1645 Hunt Building

Plants in BIRMINGHAM, CHICAGO, SALT LAKE CITY and GREENVILLE, PA. In Canada: HORTON STEEL WORKS, LIMITED, FORT ERIE, ONT.

(continued from page 56 A)

229-72.) The envelope has a plurality of separate partitioned section on the interior and a common sealing flap.

2,470,006. Stabilized fermented beverages and methods of manufacturing same. James S. Wallerstein and Ralph T. Alba, assignors to Wallerstein Company, Inc., New York, N. Y. Filed March 24, 1945. 11 claims. (Cl. 99-48.) Addition of a small quantity of water-soluble alkali lignin to beer mash shortly before the end of the boiling precipitates impurities which cause turbidity.

2,470,042. Process for flameproofing combustible cellulosic material and product resulting therefrom. Andrew McLean and Stanley F. Marrian, assignors to Imperial Chemical Industries Limited, London, England. Filed Nov. 21, 1946. 12 claims. (Cl. 117-137.) The material is impregnated with polyethyleneimine and treated with the reaction product of dipentaerythritol, orthophosphoric acid and phosphorus pentoxide.

May 17, 1949

2,470,093. Apparatus for applying wax to thin sheets. Harry Q. R. Crowder, Altadena, and Edward A. Bronson, Pasadena, Calif. Filed Aug. 6, 1945. 2 claims. (Cl. 91-51.) A method of applying wax to a very thin sheet of cellulose acetate.

2,470,150. Froth flotation of oxide iron ore. Fred D. De Vaney, assignor to Erie Mining Company, Hibbing, Minn. Filed Jan. 2, 1946. 5 claims. (Cl. 209-166.) Sodium resinate or tall oil soap is used.

2,470,174. Collapsible box. Albert M. Lewis and Peter B. Weiler, Detroit, Mich. Filed Dec. 22, 1947. 5 claims. (Cl. 229-41.)

2,470,199. Carton and secondary closure therefor. George S. Vivian, Surbiton, England. Filed Sept. 7, 1945. 2 claims. (Cl. 229-17.) The patent covers a top closure for milk cartons and the like which provides means for opening and closing the container.

2,470,261. Apparatus for handling chipper knives. Stanley D. Payzer, assignor to D. J. Murray Manufacturing Co., Wausau, Wis. Filed Oct. 9, 1944. 3 claims. (Cl. 144-176.) An apparatus is described for inserting and removing chipper knives.

2,470,262. Method of handling chipper knives. Stanley D. Payzer, assignor to D. J. Murray Manufacturing Co., Wausau, Wis. Filed Aug. 27, 1945. 1 claim. (Cl. 29-148.) Method of removing a knife blade.

2,470,267. Paper pulp agitator. John A. Rosmait, assignor to D. J. Murray Manufacturing Co., Wausau, Wis. Filed March 10, 1945. 1 claim. (Cl. 92-37.) A pulp storage and agitating chest.

2,470,270. Folding box. Jesse Srofe, assignor to Globe-Wernicke Company, Cincinnati, Ohio. Filed Aug. 29, 1946. 2 claims. (Cl. 229-9.) A folding box of telescopic construction for letters and the like.

2,470,388. Dispensing container having closure locking means. Charles O. Ball, assignor to Owens-Illinois Glass Company, Toledo, Ohio. Filed Jan. 25, 1945. 3 claims. (Cl. 229-17.) The container has a plural-ply top of sheet material.

2,470,400. Doctor blade mounting. Lloyd Hornbostel, assignor to Beloit Iron Works, Beloit, Wis. Filed April 27, 1945. 5 claims. (Cl. 92-74.)

2,470,465. Frozen food package. Frank L. Broeren, George E. Wauda, and Robert Kuehl, assignors to Marathon Corporation, Rothschild, Wis. Filed July 26, 1946. 7 claims. (Cl. 99-192.)

2,470,493. Method of making shelf edging. Edward Karfiol and William A. Roehm, assignors to Virtu, Inc., Brooklyn, N. Y. Filed Nov. 25, 1944. 4 claims. (Cl. 154-97.5.) A printed design is covered with a preformed transparent plastic appliqué.

2,470,523. Match book. Giuseppe Russo, New York, N. Y. Filed Nov. 15, 1944. 2 claims. (Cl. 206-29.) Match splints are formed of the same material as and integrally with the cover.

2,470,577. Complex calcium cabonate-silicate pigment product and method of making same. Howard F. Roderick and Fritz M. Zorn, assignors to Wyandotte Chemicals Corporation, Wyandotte, Mich. Filed Oct. 11, 1945. 5 claims. (Cl. 106-306.)

2,4 70,641. Disintegrated newsprint-boric acid insulation composition. Frederick G. Portz, Waukesha, Wis. Filed May 12, 1945. 2 claims. (Cl. 252-62.) A mixture of 25 pounds of boric acid and 75 pounds of disintegrated newsprint.

May 24, 1949

2,470,764. Method of treating waste sulfite liquor. Thomas L. Dunbar, Watertown, N. Y. Filed Sept. 23, 1943. 10 claims. (Cl. 92-11.) The waste liquor is treated with an oxidizing agent, such as bleach liquor or hydrogen peroxide; the filtrate is treated with sodium chloride to precipitate sodium lignosulphonate. The second filtrate can be used for pulping.

2,470,789. Siftproof bag. Frank D. Palmer, assignor to Frank D. Palmer, Inc., Chicago, Ill. Filed Nov. 26, 1945. 2 claims. (Cl. 229-17.)

2,470,984. Container construction. Raymond H. Horning and Isaac L. Wilcox, assignors to Oswego Falls Corporation, Fulton, N. Y. Filed Sept. 7, 1944. 10 claims. (Cl. 229-5.5.) The patent covers the closure of a rectangular container for liquid products.

2,471,017. Isaac L. Wilcox, assignor to Oswego Falls Corporation, Fulton, N. Y. Filed Dec. 4, 1946. 4 claims. (Cl. 229-5.5.) The major portion of the end closure of the container is permanently and fixedly sealed to the body and the remainder can be moved to provide a pouring opening.

2,471,147. Folding berry box. James Gagnon, Olalla, Wash. Filed Sept. 8, 1947. 2 claims. (Cl. 229-16.)

2,471,173. Fiberboard container for disk-shaped articles. William H. Taylor, assignor to Sears, Roebuck and Co., Chicago, Ill. Filed July 27, 1945. 2 claims. (Cl. 229-87.) A container is designed for packaging circular saws.

2,471,330. Method of continuously coating porous sheets. George D. Knight and Ben W. Rowland, assignors to The Institute of Paper Chemistry, Appleton, Wis. Filed Feb. 17, 1947. 4 claims. (Cl. 117-61.) A method of continuously coating a porous sheet consists in evacuating the fluid ingredients from a region adjoining and within a surface of a sheet, removing the evacuated region to a coating zone, and promptly applying fluent coating material to the removed region under at least atmospheric pressure and continuing the operation.

2,471,384. Froth flotation of sulphide ores. Robert B. Booth and Roy A. Pickens, assignors to American Cyanamid Company, New York, N. Y. Filed May 16, 1946. 3 claims. (Cl. 209-167.) Various salts of lignosulphonic acid can be used.

May 31, 1949

2,471,482. Means for creasing linings for books and for analogous purposes. Lionel J. B. R. French, assignor to The Book Machinery Company Limited, London, England. Filed Nov. 1, 1946. 4 claims. (Cl. 154-41.)

2,471,607. Facsimile recording papers. Frank G. Calkin, assignor to Finch Telecommunications, Inc., Passaic, N. J. Filed Jan. 9, 1947. 1 claim. (Cl. 204-2.) A conductive paper (containing about 40% graphite) is coated with a mixture of lead formate, titanium dioxide, zinc dust, polyvinyl acetate, and ethyl acetate.

2,471,632. Retarded cement. Norman C. Ludwig, assignor to Universal Atlas Cement Company, Chicago, Ill. Filed Feb. 12, 1947. 4 claims. (Cl. 106-93.) From 0.03 to 0.27% (by weight of the cement) of an oxycellulose or its salt is added.

2,471,714. Stabilized dry rosin size composition. Justus C. Barthel, Arnold R. Davis, and Edward N. Poor, assignors to American Cyanamid Company, New York, N. Y. Filed May 22, 1948. 2 claims. (Cl. 106-218.) A stabilized rosin size contains from 0.1 to 1% phenothiazine (based on the weight of the rosin).

2,471,750. Photoelectric glossmeter. Richard S. Hunter, assignor to Henry A. Gardner Laboratory, Inc., Bethesda, Md. Filed Feb. 20, 1948. 6 claims. (Cl. 250-41.5.)

2,471,883. Box and corner lock therefor. Paul W. Miessler, assignor to The Hankins Container Company, Cleveland, Ohio. Filed Nov. 22, 1946. 6 claims. (Cl. 229-45.) The patent covers a corner lock for folded boxes.

2,471,932. Molded pulp apparatus and method. Merle P. Chaplin, South Portland, Maine. Filed Dec. 23, 1941. 24 claims. (Cl. 92-54.) The construction of a pulp molding machine is described.

June 7, 1949

2,472,183. Container. Marshall I. Williamson, assignor to National Folding Box Company New Haven, Conn. Filed Oct. 23, 1945. 6 claims. (Cl. 206-45.31.) The container has an inspection window.

2,472,308. Segmental chute for loading materials. James O'Halloran, assignor to Anglo-Canadian Pulp and Paper Mills Limited, Quebec, Canada. Filed Feb. 10, 1947. 5 claims. (Cl. 302-14.) A method is proposed for loading pulpwood into a stowage space.

2,472,335. Method of flameproofing combustible cellulosic materials. Andrew McLean and Stanley F. Marrian, assignors to Imperial Chemical Industries Limited, London, England. Filed Nov. 15, 1945. 6 claims. (Cl. 117-137.) The material is impregnated with polyethyleneimine and then treated with pentaerythritol tetraorthophosphate.

2,472,440. Machine for fabricating packages. Leroy L.

(continued on page 60 A)

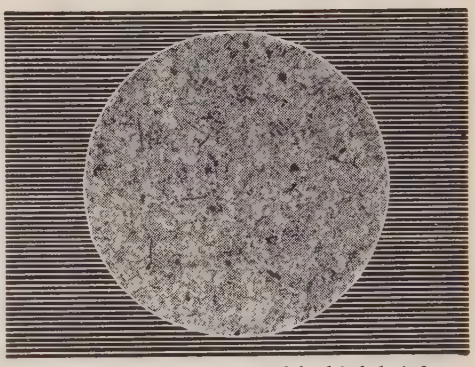
How to reduce the cost of high brightness

If high cost is forcing you to sacrifice high brightness in your paper, here is a suggestion that may be of help:

Try using Celite in combination with titanium dioxide in the furnish. You'll probably find, as many mill men have, that you can get equal or better dry brightness and opacity at considerably lower cost than if TiO_2 is used alone.

The reason for this is due not only to the high intrinsic brightness of two specially developed grades of Celite but also to their excellent suspension properties. This makes for high retention —not only of the Celite itself, but also of the titanium dioxide. Thus, the usual percentage of TiO_2 goes further . . . does more work . . . and high brightness and opacity are obtained at a lower cost.

The use of small amounts of Celite in the furnish also has the desirable effect of noticeably improving the surface finish of the sheet, and, therefore, its printing qualities.



Photomicrograph of one of the high-brightness grades of Celite widely used with TiO_2 to obtain high brightness at low cost.

A Celite engineer will be glad to discuss how this economical combination of Celite and TiO_2 will help you obtain high brightness in your product. Write Johns-Manville, Box 290, New York 16, N. Y.

Johns-Manville ***CELITE PRODUCTS***

for the paper industry

(continued from page 58 A)

Salfisberg, assignor to Ivers-Lee Company, Newark, N. J. Filed March 7, 1946. 6 claims. (Cl. 93-3.)

2,472,516. Carton. Kenneth T. Buttery, assignor to Sutherland Paper Company, Kalamazoo, Mich. Filed July 12, 1946. 6 claims. (Cl. 229-30.) A carton is described which is suitable for the display of mechandise (fruit and bakery products).

2,472,521. Packaging. George M. Danenbauer, assignor to The Diamond Match Company, New York, N. Y. Filed Feb. 14, 1946. 2 claims. (Cl. 93-3.) A dispensing carton for waxed paper and its construction.

2,472,591. Method of preparing an oxidized nitrated cellulose. William O. Kenyon and William F. Fowler, Jr., assignors to Eastman Kodak Company, Rochester, N. Y. Filed March 29, 1946. 6 claims. (Cl. 260-220.) Cellulose is treated with liquid nitrogen dioxide and nitric acid in carbon tetrachloride.

2,472,674. Duplex box or carton. Emil Morand, Jersey City, N. J. Filed Oct. 31, 1947. 6 claims. (Cl. 229-36.) The construction is such that, when folded, two complete but separable box members are formed.

2,472,698. Knockdown carton. Anthony G. Edtmiller, assignor to Hummel and Downing Company, Milwaukee, Wis. Filed Sept. 20, 1947. 14 claims. (Cl. 229-41.)

June 14, 1949

2,472,790. Method of preparing starch paste. James P. Casey, assignor to Stanley Manufacturing Company, Decatur, Ill. Filed April 20, 1946. 11 claims. (Cl. 195-66.) The objectionable thickening which occurs in a concentrated fluid starch paste can be overcome by using a mixture of starches, each of which has a substantially different pasting or enzyme-converting temperature.

2,472,877. Washing cellulose. John W. Allquist, assignor to Celanese Corporation of America, New York, N. Y. Filed June 28, 1944. 3 claims. (Cl. 8-137.) The cations normally found in industrial water and adsorbed by the cellulose can be removed by washing with ordinary salt-bearing industrial water which has been acidified with an inorganic acid to pH 2 to 5 and washing out the displaced cations and the acid with demineralized water.

2,472,883. Method and apparatus for producing cartons. Samuel Bergstein, Cincinnati, Ohio, assignor to Robert M. Bergstein and Frank D. Bergstein. Filed Sept. 12, 1946. 11 claims. (Cl. 93-52.) A carton blank is passed through embossing rolls so that the embossing is confined to the body walls only in order to provide a cushioning effect for fragile articles.

2,472,985. Container. Edward A. Pardee, assignor to Shellmar Products Corporation, Chicago, Ill. Filed Oct. 23, 1946. 6 claims. (Cl. 229-15.) The construction of a self-locking razor blade utility carton is claimed.

2,473,055. Reclosing carton. Reynolds Guyer, assignor to Waldorf Paper Products Company, St. Paul, Minn. Filed Jan. 5, 1945. 1 claim. (Cl. 229-37.) A reclosable carton, suitable for packaging smoking tobacco is so constructed that a portion of the walls are of double thickness.

2,473,069. Apparatus for manufacture of paper. Nicholas J. Niks, Munising, Mich. Filed April 27, 1945. 7 claims. (Cl. 92-44.) The construction of a breast roll is described.

2,473,100. Paper machine wire stringing device. Lloyd Hornbostel, assignor to Beloit Iron Works, Beloit, Wis. Filed June 14, 1944. 23 claims. (Cl. 92-44.) The method consists in draping a forming wire in an open loop in the aisle adjacent to the wet end of a Fourdrinier machine and moving this open loop into the line of the machine around the entire table or around the couch roll only.

2,473,190. Method of producing fibrous building compositions. Charles M. Baskin and Norman W. McLeod, assignors to Standard Oil Development Company, Linden, N. J. Filed July 1, 1944. 13 claims. (Cl. 92-21.) Bagasse is mixed with flux oil and after two weeks digested with lime; the product is mixed with a clay-water-asphalt slurry and formed into a board.

2,473,243. Coating machine for flexible sheet materials. Joseph Ettl, assignor to Rogers Industries, Inc., New York, N. Y. Filed July 3, 1946. 6 claims. (Cl. 91-50.) A glue-applying machine.

2,473,269. Papermaking machine. Charles S. Adams, assignor to Rice Barton Corporation, Worcester, Mass. Filed Sept. 2, 1944. 6 claims. (Cl. 92-43.) The patent covers a method of laying paper stock on an endless traveling wire.

2,473,270. Cylinder mold papermaking machine. Charles S. Adams, assignor to Rice Barton Corporation, Worcester, Mass. Filed Sept. 2, 1944. 3 claims. (Cl. 92-43.) Among the purposes of this invention is to provide a cylinder mold papermaking machine in which the paper web is laid on a revolving screen surface.

2,473,391. Container. Walter A. Roselle, New York, N. Y. Filed Oct. 23, 1946. 7 claims. (Cl. 229-7.) The container is leakproof, in which the closure member can be unsealed and released and opened when desired.

2,473,461. Hydraulic barking machine. Frank O. White, Edmundston, New Brunswick, Canada. Filed May 19, 1945. 9 claims. (Cl. 144-208.) Provision is made for the automatic relative positioning of the nozzles and the log, so that the nozzles are pointed radially toward the axis of the log.

2,473,473. Method of preparing regenerated cellulose. Gordon D. Hiatt and Carlton L. Crane, assignor to Eastman Kodak Company, Rochester, N. Y. Filed Feb. 5, 1945. 5 claims. (Cl. 106-168.) Cellulose is dissolved in a mixture of nitrogen dioxide and trioxide and the solution coated onto a film-forming surface.

2,473,492. Reclosable carton. Frank C. Shina, Thomson, N. Y., assignor to United Board Carton Corporation. Filed Aug. 1, 1945. 2 claims. (Cl. 229-17.) A carton has a closure flap which can be partially separated from the body of the carton and repeatedly returned to the closed position.

June 21, 1949

2,473,517. Adhesion testing machine. Doris M. Freedman, New York, N. Y. Filed Aug. 6, 1945. 10 claims. (Cl. 73-150.) The test strip is pulled from the plate at a uniform rate, a pull or tension-indicating device being used to indicate the force used throughout the stripping.

2,473,582. Carton for radio tube and the like. Vernon D. Goodwin, assignor to Sylvania Products Inc., Emporium, Pa. Filed June 18, 1946. 1 claim. (Cl. 229-6.) A protective shell for radio tubes is formed from a single length of cardboard.

2,473,635. Display carton with support. Kenneth T. Buttery, assignor to Sutherland Paper Company, Kalamazoo, Mich. Filed Oct. 8, 1945. 7 claims. (Cl. 206-45.26.) A carton is claimed having an easel incorporated therein, the cover of which can be adjusted to an erected position for display.

2,473,656. Machine for forming article supporting pallets for wrapping machines. Norman W. Lyon and Roland E. Brown, assignors to Package Machinery Company, East Longmeadow, Mass. Filed Dec. 12, 1947. 6 claims. (Cl. 154-30.) A device is described for cutting and forming supporting cards or pallets for candy bars for wrapping.

2,473,766. Box partition. Ralph C. Richey, assignor to American Box Board Company, Grand Rapids, Mich. Filed July 26, 1948. 5 claims. (Cl. 229-42.) The box partition structure includes two members or elements, each made from flat paper stock.

2,473,836. Paper cup beader. Paul E. Wixon and Clarence E. Chapman, Baltimore, Md., assignor to Joseph Shapiro. Filed Jan. 29, 1948. 5 claims. (Cl. 93-36.5.) A mechanism is described for providing a cup with a bead at a predetermined distance from the top edge.

2,473,840. Conical paper cup with rounded bottom. Walter E. Amberg, assignor to Lily-Tulip Cup Corporation, Chicago, Ill. Filed Dec. 4, 1947. 2 claims. (Cl. 229-1.5.) A paper cup of conical form has the bottom rounded to a substantial distance from the apex of the cone from which the cup is formed.

2,473,932. Package for dispensing interfolded sheets. Gaylord E. Wolf, Pittsburgh, Pa. Filed April 30, 1947. 4 claims. (Cl. 206-57.) A packaging arrangement for cleansing tissues.

2,473,954. Treatment of alkali cellulose. Guillaume M. A. Kayser, assignor to American Enka Corporation, Enka, N. C. Filed Nov. 18, 1946. 3 claims. (Cl. 260-233.) The aging of alkali cellulose is prevented by addition of about 0.08% sodium trithiocarbonate.

2,474,034. Bleaching poplar groundwood. Kenneth A. Craig, assignor to Paper Patents Company, Neenah, Wis. Filed Dec. 4, 1946. 2 claims. (Cl. 8-106.) Poplar groundwood slurry of about 2 to 40% oven-dry consistency is treated at 25 to 50° with an alkali and a hypochlorite; sufficient hypochlorite is used to provide 7 to 15% of available chlorine on the oven-dry pulp. The pH is maintained at 9 to 11 through the bleaching operation. Finally, the pulp suspension is acidified to a pH 5 to 5.5. The process can be applied to rot-infected pulp.

2,474,052. Doctor operating mechanisms. Anton W. Johnson, Masson, Quebec, Canada. Filed May 6, 1946. 1 claim. (Cl. 92-74.) The invention provides for a doctor-actuating device which is automatically operable in response to the movement of the usual spring roll.

2,474,076. Dispensing container. Claude H. Thompson, Binghamton, N. Y. Filed Dec. 17, 1946. 7 claims. (Cl. 312-39.) A dispensing container for a roll of paper.

June 28, 1949

2,474,292. Adhesive tape for laminating. Charles L. Weidner, New Brunswick, and Laszlo W. Eger, Perth Amboy, N. J., assignors to Industrial Tape Corporation. Filed Aug. 13, 1943. 3 claims. (Cl 117-122.) The adhesive mixture for a laminating tape for plywood consists of synthetic resins.

(continued on page 62 A)

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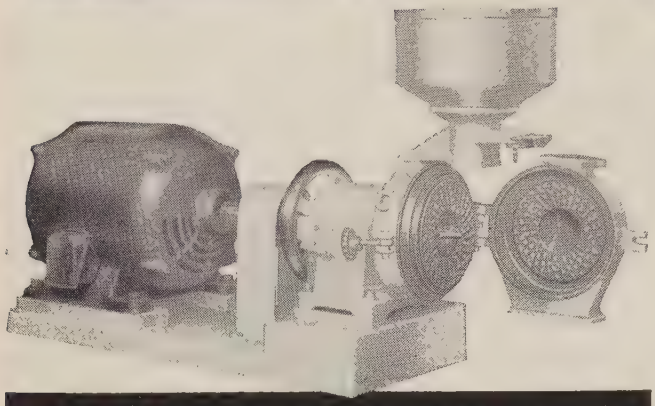

Bauer NO. 148-1E LABORATORY MILL

For the study of fiber treating possibilities, this new 8-inch disc mill has a place in every laboratory. Small batches can be pulped for investigating many kinds of materials. These tests are particularly useful in predicting the behavior of semi-chemical cooked pulps. One of the outstanding advantages of the Laboratory Mill is its usefulness in quickly plotting beating curves. The Laboratory Mill can be employed for dry or wet grinding. When used for the latter purpose, it is equipped with a shower for adding water.

Since the head of the mill can be swung open for cleaning the interior, entire samples of test quantities can be recovered. The hinged door is also a convenience for changing plates, which are available in a variety of designs.

The mill is equipped with a 3- or 5-h.p. built-in motor or a sheave for V-belt drive. It will accept up to 20 h.p. input. The head is water cooled to dissipate frictional heat.

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You are invited to request literature and data.

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SPRINGFIELD 99, OHIO

(continued from page 60 A)

2,474,306. Cellulosic products. Leonard Doub, assignor to Parke, Davis & Company, Detroit, Mich. Filed Feb. 23, 1945. 6 claims. (Cl. 260-212.) In a fiber containing from 2 and 23% carboxyl groups, a part is in the form of its reaction product with a high molecular weight quaternary ammonium salt wetting agent.

2,474,391. Process for producing packing structures. Samuel Bergstein, Cincinnati, Ohio., assignor to Robert M. Bergstein and Frank D. Bergstein. Filed Oct. 26, 1945. 5 claims. (Cl. 18-56.) Board is passed through a bath of water, between press rolls, and then molded between heated die members.

2,474,398. Surface fluxing coated liner. Clark C. Heritage, assignor to Wood Conversion Company, St. Paul, Minn. Filed April 21, 1943. 17 claims. (Cl. 154-33.05.) A method of making a creped sheet resistance to water vapor.

2,474,476. Carton. Reynolds Guyer, assignor to Waldorf Paper Products Company, St. Paul, Minn. Filed Dec. 9, 1944. 4 claims. (Cl. 229-5.5.)

2,474,523. Triple-edge reclosing carton. Reynolds Guyer, assignor to Waldorf Paper Products Company, St. Paul, Minn. Filed June 16, 1945. 3 claims. (Cl. 229-43.)

2,474,543. Flower holder and box. Roderick I. McLellan, assignor to E. W. McLellan Co., San Francisco, Calif. Filed April 2, 1948. 5 claims. (Cl. 206-45.14.)

2,474,619. Heat-sealable sheet material. Robert A. Farrell and Charley L. Wagner, assignors to Marathon Paper Mills Company, Rothschild, Wis. Filed Jan. 22, 1944. 10 claims. (Cl. 154-50.) A heat-sealable packaging material consists of a relatively impermeable base sheet material and a relatively porous tissue sheet adhered by a thermoplastic adhesive film.

2,474,691. Web coating apparatus. William A. Roehm, assignor to Virtu, Inc., Brooklyn, N. Y. Filed March 20, 1946. 12 claims. (Cl. 91-43.) A fountain method of coating.

2,474,700. Diazotype sensitized papers having cellulose ether sizing. Sam C. Slifkin, assignor to General Aniline & Film Corporation, New York, N. Y. The paper is precoated with a surface sizing agent of a cellulose ether.

2,474,704. Method of rendering materials water-repellent. Mary E. Thayer, assignor to Dow Corning Corporation, Midland, Mich. Filed Aug. 11, 1948. 8 claims. (Cl. 99-141.) The material is contacted with the vapor of monomethyldiethoxysilane.

2,474,751. Foldable compartment box. Emil Morand, Jersey City, N. J. Filed March 21, 1946. 4 claims. (Cl. 229-28.)

2,474,770. Bag and method of making the same. Stanley G. Yount and Paul R. Halstead, assignors to Southland Paper Converting Company, Los Angeles, Calif. Filed May 15, 1944. 7 claims. (Cl. 229-53.) The bag is adapted to open into a receptacle of substantially rectangular cross section.

2,474,775. Method and apparatus for simultaneously securing together and perforating paper webs. William G. Borchers, assignor to Autographic Register Company, Hoboken, N. J. Filed Nov. 12, 1946. 15 claims. (Cl. 93-61.) A method of fastening together a pair of superposed piles of stationery.

2,474,783. Carton. Fred C. Gluck, assignor to Minerva Wax Paper Company, Minerva, Ohio. Filed April 8, 1946. 3 claims. (Cl. 206-58.) A carton for dispensing waxed paper.

2,474,801. Fibrous sheets formed from an aqueous suspension of a mixture of fibers and butadiene-styrene copolymer. Allen F. Owen, assignor to Latex Fiber Industries, Inc., Beaver Falls, N. Y. Filed Sept. 15, 1945. 4 claims. (Cl. 92-3.) A paper sheet contains about 25 parts by weight of an emulsified copolymer of butadiene and styrene per 100 parts of papermaking fibers. The polymer is added to the fibers in the beater. The treated paper has increased tensile strength and initial tearing strength; the elongation at break is also increased.

ANNUAL MEETING

TAPPI

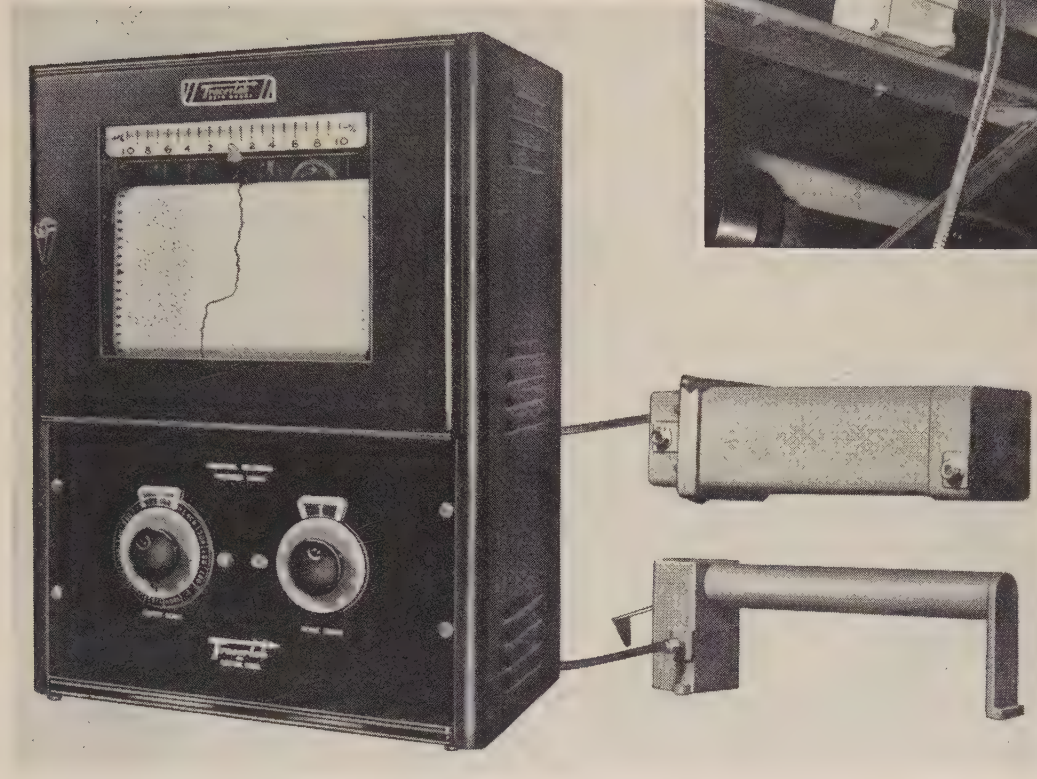
Commodore Hotel
New York, N. Y.

February 20–23, 1949

CUT COSTS

BY IMPROVING BASIS WEIGHT CONTROL

A Tracerlab Beta Gauge installation for measuring paper board at Continental Paper Co., Ridgefield Park, New Jersey.



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ELIMINATE OFF-WEIGHT REJECTS • DECREASE VARIATIONS ACROSS SHEET

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The Tracerlab Beta Gauge is a completely new and unique instrument for measuring and recording weight per unit area or thickness of various materials directly on the production line. It uses beta radiation from Oak Ridge produced radioisotopes to achieve a high degree of accuracy and sensitivity and is unaffected by variations in chemical composition of the material being measured. This is a non-contacting type of gauge designed for the severe operating conditions usually encountered in production operations. In addition to the recording type, a non-recording industrial model and a laboratory model of the Tracerlab Beta Gauge are also available.

Let us know your gauging problems and we will gladly advise you how the Tracerlab Beta Gauge can help you.

Write for Beta Gauge Bulletin T-20

A FEW TYPICAL USES

Measuring weight per unit area or thickness of the following:

PLASTIC COATED PAPER
PAPER BOX BOARD
TISSUE PAPER
STATIONERY
PAPER BUILDING BOARD
LEDGER PAPER
CONDENSER PAPER
WAXED PAPER
PARCHMENT
FACIAL TISSUE
ASPHALT COATED PAPER
CARBON PAPER
KRAFT
GLASSINE PAPER

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New York Office
General Motors Building, 1775 Broadway, New York 19
Midwest Office
LaSalle-Wacker Bldg., 221 N. LaSalle St., Chicago, Ill.

TRACERLAB INC. 130 HIGH STREET, BOSTON 10, MASS.

LOCAL SECTION ACTIVITIES

Reports of Meetings, Personnel and Events

New England

The New England Section held its first meeting of the 1949–1950 season at the Red Lion Inn, Stockbridge, Mass. on Sept. 30, 1949. 140 people were in attendance. Fritz Klein of Byron Weston Co., Dalton, Mass. was Chairman of the meeting. The theme of the meeting was Tub sizing. The speakers were limited to 10 minutes and a panel discussion followed.

Mr. R. A. Gale of Pillsbury Mills, Inc. spoke on "Enzyme Conversion." He particularly stressed flexibility as one of the prime advantages of this type of starch treatment. Premeasured enzyme units were cited as a step in the direction toward simpler and more precise use of enzymes in starch conversion.

Richard Tutt of Peter Cooper Corp., discussed "Glues." He stated that strong acid or strong alkali will hydrolyze these colloids ultimately destroying their film-forming properties. Hide glue is normally used for tub sizing where it imparts increases in fold, tear, burst and eraser resistance. A degree of wet strength is obtained when glue-tubbed paper is treated with formaldehyde. Overheating tends to break down the film-forming properties of glue. Alum is sometimes used for viscosity control. Mr. Tutt brought out the fact that the degree of dryness of the sheet sometimes causes foaming of the glue solution at the tub due to the fact that air entrained in the paper builds up in the glue solution.

J. M. Newton of Clinton Industries, Inc. stated that there are six types of starch usually used for tub sizing. These are as follows: Common starch is seldom used; Acid modified starch now practically extinct in tub sizing; Dextrinized; Chlorinated starches; Enzyme converted starches; and Pregelatinized starch.

P. B. Holden of Stowe-Woodward Co., stated that there is a high divergence in the density and crowns of press rolls used by mills making similar grades of paper. He indicated for the most part that these specifications depend on the whims of paper production men. He stated that to some extent the penetration of tub sizing solutions into sheets depended on roll hardness. The harder the roll the greater the penetration. The average size press today uses a hard top-roll. The top size-press roll is generally ground straight faced with a zero crown. The degree of crown of the bottom roll varies from mill to mill.

O. R. Steffens of Penick & Ford, Ltd., Inc., discussed the procedure in making up starch solutions for tub-size application. He stated that 0.2–0.3% paraformaldehyde based on the weight of the starch is recommended to prevent souring of starch solutions held over for any period of time. For sterilizing wooden tanks contaminated with bacteria, he recommended 3.5 ounces of paraformaldehyde per 100 gallons of water. This solution should be boiled in the tank for a period of 4 to 5 hours. Concerning degree of penetration, Mr. Steffens stated "that other factors being equal, a thin size of the same concentration will soak into the sheet and the excess is removed from the surface. Higher viscosity size will leave a heavier film on the sheet. All size being the same concentration will result in the same percentage weight. Increasing temperature will thin the size and give greater soak into the sheet. Changing the weight of the press rolls by loading apparently does not change the weight of the starch picked up. A sheet having 5 or 6% moisture going into the size press will pick up a higher percentage of starch than a sheet having 2 or 3% moisture."

Robert Pattison of Cellulose Fibres, Inc., discussed some of the practical operating problems encountered with the use of starch solutions on the paper machine. He differentiated between a size press and tub-size applications. He stated that the difference between these two methods is that the surface size or size press application picks up approximately 25% less starch than the tub-sizing operation.

Chicago

The Chicago Section met at the Chicago Bar Association, Chicago, Ill., on October 17. Louis W. Mead, Chicago Sales Manager of Tracerlab, Inc., talked on "The Role of Radioisotopes in the Paper Industry." A motion picture "Waxes for Protective Packaging" was shown by representatives of the Socony-Vacuum Oil Co.

Empire State

Hudson Valley Group

The Hudson Valley Group met at the Village Inn, So. Glens Falls, N. Y., on October 20. S. A. Tomkins, Field Engineer of the Johns-Manville Corp., discussed the general application of Transite pipe, insulation and other J-M products in the pulp and paper industry.

Metropolitan Group

The Metropolitan Group of the Empire State Section met at Fraunces Tavern, New York City, on October 11. John B. Calkin presided as Chairman.

Henry Perry introduced the speaker of the evening, George Brooks. Mr. Brooks is research and educational director of the International Brotherhood, Pulp Sulphite & Paper Mill Workers, A. F. of L. He is a former instructor at Brown University and was later connected with the National Labor Relations Board and the War Production Board.

Mr. Brooks started his talk by stating that the aim of his talk was to explain "Why Unions are Good Things." He sincerely believes that unions are not only good for employees but also for management. This is so for three major reasons: 1. Unions have aided and assisted the process of technological changes. Unions smooth the way for technological changes and these changes have taken place with frictionless ease in the pulp and paper industry. In fact, there have been more strikes against new machines in nonunion plants than in union plants. Unions favor technological changes because they are just as proud of the part the industry plays in the national economy as is management. Unions ease the process of technological changes by setting up rules governing the placement of employees under the new set-up so that they will not fear the loss of their jobs and become antagonistic toward the change. These rules are: first, the company gives advance notice of the new setup to all employees, second, the oldest man on the job gets first crack at the new machine or the new job, third, the displaced persons have seniority in moving up to this new job. Meanwhile they must be placed in other jobs elsewhere in the plant, and fourth, the new job shall pay more money.

An example was cited in the case of the installation of

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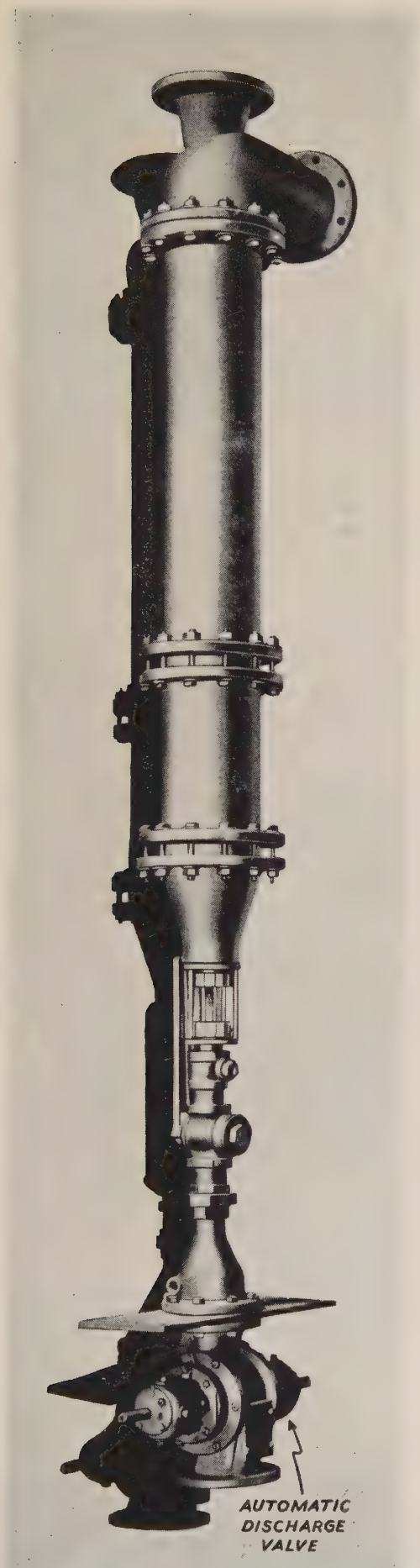

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Rifflers and settler systems are obsolete, comparatively inefficient, wasteful and unclean systems.

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(continued from page 64 A)

a hydraulic barker in a mill out West. A hydraulic barker was introduced to take the place of the old type barker. Whereas a crew of 30 men worked under unpleasant and difficult conditions, one man and an assistant operated the new machine under clean pleasant conditions and at an hourly rate almost double the old rate.

Unions aid the process of technological changes by convincing the workers of the wisdom and desirability of such changes. Workers' consent and willingness to these changes are tremendously important to their successful operation. The unions accept this challenge of convincing the workers of the need for the new machine. They are committed to the greatest possible changes because it means more secure employment for their members through larger markets for the products of the industry.

2. Unions are good things because they have improved the working conditions for the employees. Unions have introduced orderly procedures for settling grievances among the workers so that there will be no loss of work or time on the job. This helps management also because now they know who are the discontented and can take steps to remove the causes if valid, whereas before they had no way of knowing what was in the minds of their workers. Management frequently complains about the number of such "gripes," especially of the number of patently unfounded grievances. They feel that the union should screen them. However, the unions' position is that all grievances should be made public and be heard whether they are judged right or wrong. The purpose is to let all the workers know that they will always get a fair hearing even though their complaint is unfounded and rejected.

3. Unions are good things because they attempt to explain to the workers the part their job and their industry takes in the national economic picture. Unions help to upgrade workers. Unions try to explain the need for investing money in keeping a plant modernized in order that it can stay in business at a time when it cannot afford a rise in pay. Unions accept the responsibility of explaining the incentive plan to workers. At the same time, unions ask management to help them do this by making the incentive plan simple and easily understood by the workers. A plan requiring the understanding of the calculus in order for a worker to figure out what his weekly earnings are, is not practical. The company should also admit the limitations of the incentive plan when they exist.

The speaker concluded by saying that unions are here to stay and it would be so much easier for all concerned if management would accept them and go along with them for the good of the industry.

This was followed by a question and answer period.

Question: Just how much should the government intervene in labor relations problems?

Answer: Where a company gets along with the union, there is no need for government intervention. However, where a company opposes union organization, the unions want whatever government help they can get such as the N.L.R.B.

Question: Why do unions dislike the Taft Hartley Act?

Answer: There are two reasons: First, the use of the labor injunction preventing the right to strike. The union feels it is very difficult to explain labor relations problems to a judge. Second, the supercedence of state laws over federal laws. For example, where two states have different laws governing labor relations, a union would have to negotiate two different contracts for companies having plants in two different states. This may happen in many situations.

During the general discussion that followed the formal question and answer period, one very pertinent comment was made from the floor to the effect that management and technical people in particular, could certainly go along with unions insofar as the first function was stated, namely to assist an orderly process of technological change in the industry.

On November 8 John Cornell of Paper Mill News reviewed his earlier prognostications concerning the future events of 1949. Some bulls eyes, some near misses, and a few strike-outs.

The next meeting of the group will be held on January 10. A. P. Schreiber of Tracerlab, Inc., will discuss the Application of Nuclear Energy Techniques to Papermaking.

Northern New York Group

The Northern New York Group met on October 13 at the Woodruff Hotel in Watertown, N. Y. The dinner preceding the meeting was attended by 106 members and visitors which is the largest attendance so far for this group. J. H. Heuer, (St. Regis Paper Company) Chairman of the Northern Group, presided at the meeting and introduced the speaker of the evening, Richard T. Trelfa, Hercules Powder Co., Kalamazoo, Mich. Mr. Trelfa's subject was "The Use of Statistics in Controlling Quality in a Paper Mill," which was presented in down-to-earth layman's language. The use and limitations of various statistical methods were explained and the precautions advisable for those starting to use these methods were stressed.

Western New York Group

The Western New York Group met on October 12, at the plant of the Coated Products Division of the Carborundum Co., at Wheatfield, N. Y. As guests of the Carborundum Co., approximately 50 members were treated to a tour of the new coated products plant with its 500,000 square feet of floor space devoted to the production of these materials. A feature of the trip was the inspection of the No. 7 machine which is the largest and most modern coated-abrasive machine of its type in the world.

After the mill visit, the members were greeted by E. Dent Lockey, Assistant Director of Industrial Relations for the Carborundum Co., who gave an interesting talk on the founding of the company and its growth to present importance in the abrasive field. A movie "Romance of an Industry" which showed the preparation of the abrasives and some of their outstanding industrial uses, followed Mr. Lockey's address.

A discussion of the types of raw materials used for the coating base and their defects was then presented by G. J. Keller, plant superintendent at Wheatfield. Uniformity of basis weight and caliper of the paper was particularly important in the production of good coated abrasives.

Following the excellent dinner served in the cafeteria of the Carborundum Co., the members of the Western New York Group enjoyed a talk by W. W. Barrett, Sales Engineer for Paper Mill Abrasives for the Carborundum Co. on "Pulpstones." Mr. Barrett traced the development of pulpstones from the natural sandstones to the first synthetic pulpstones and their subsequent improvement to the modern pulpstones now in general use in groundwood industry. Mr. Barrett's talk was illustrated by slides showing the construction of pulpstone segments and the types used for the preparation of different grades of groundwood pulps such as insulating board, newsprint, and magazine stock.

The meeting was conducted by J. S. Reichert of the Du Pont Co., Chairman of the Western New York Group. B. J. Staneslow, Moore Business Forms, and Program Chairman, announced that a meeting has been scheduled jointly with the Canadian Group for November 9 at the Prospect House in Niagara Falls. John P. Burke, Presi-

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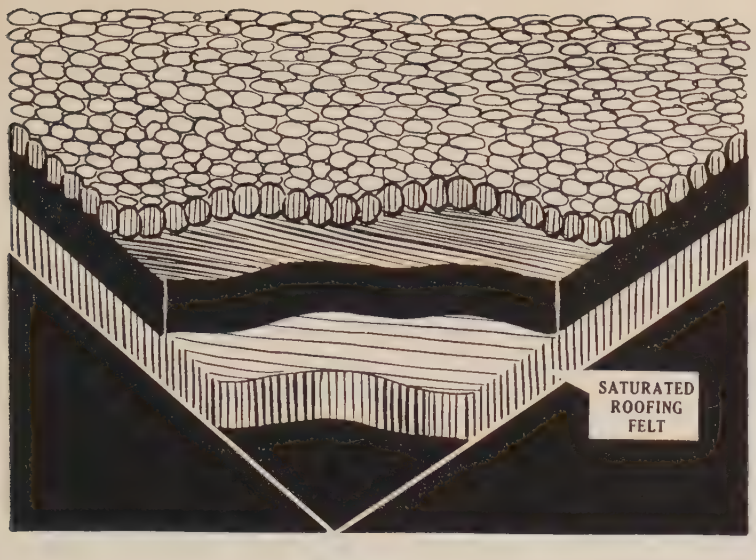


Saturating felts . . .

with high wood-pulp additions.

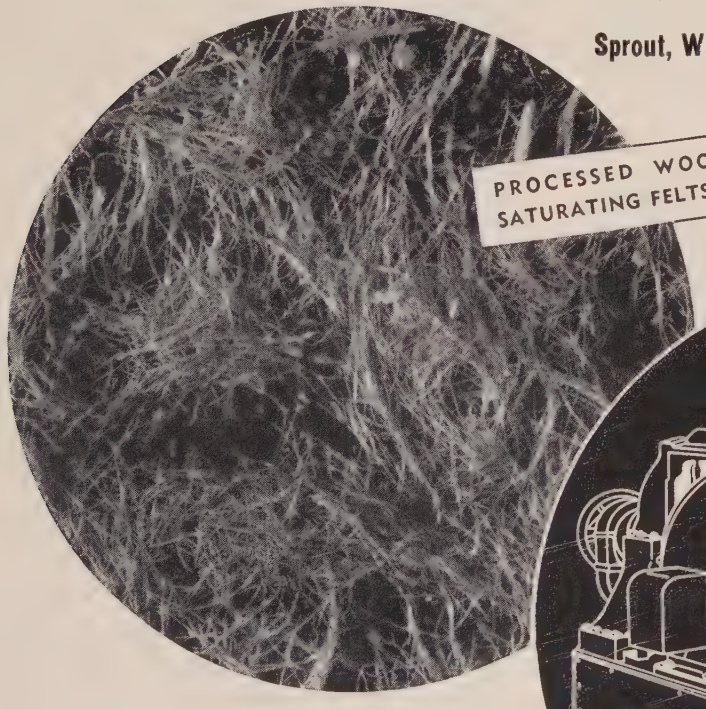
Because of lower manufacturing costs, modern dry felt producers are looking to wood pulp as a partial replacement for rags in the furnish.

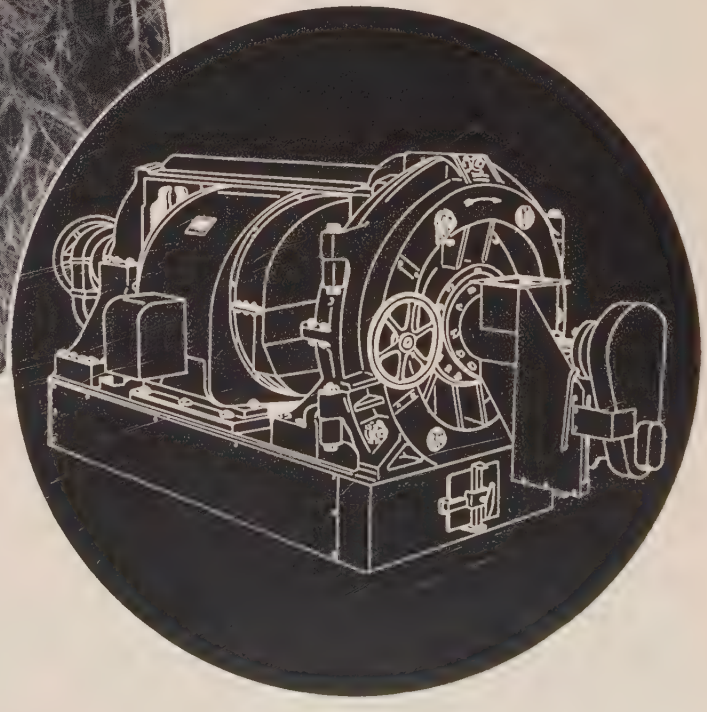
On this service, Sprout-Waldron Refiners are the natural complement to the preliminary attrition of the heat and chemically softened wood chips. They assure high tonnages and discharge the pulp as slender fibers without degradation.

In felt production, S-W Refining improves quality and uniformity of saturation. Excellent folding properties are maintained.

Let us consult with you on your problem.

Sprout, Waldron & Co., Inc., 38 Waldron St., Muncy, Pa.





SPROUT WALDRON
Manufacturing Engineers
MUNCY · PENNSYLVANIA

45

(continued from page 66 A)

dent of the International Brotherhood of Pulp, Sulphite, and Paper Mill Workers will address the joint assembly and a very large attendance is anticipated.

Lake Erie Papermakers

The Lake Erie Papermakers and Converters Association held its first meeting at the Hickory Grille, Cleveland, Ohio, on October 7. Lew Burnett presided as temporary chairman. About 150 attended.

R. G. Macdonald, Secretary-Treasurer of the Technical Association gave a brief outline covering the history of the establishment of local sections in the Association and presided at the election of officers.

E. L. Lukemine, on behalf of the Organizing and Nominating Committee presented the following slate which was elected unanimously.

Chairman: Lewis K. Burnett, Ohio Boxboard Co., Rittman, Ohio
First Vice-Chairman: W. O. Manor, Consolidated Paper Co., Monroe, Mich.
Second Vice-Chairman: C. Peter Spring, Chase Bag Co., Chagrin Falls, Ohio
Secretary-Treasurer: Wm. Schoenberg, Lord & Schoenberg, 1200 West 9th St., Cleveland, Ohio
Executive Committeemen:
Arthur W. Cheely, Hankins Container Co., Cleveland, Ohio
Earl O. Knapp, Auglaize Paper Box Co., St. Marys, Ohio
Arthur J. Goetz, River Raisin Paper Co., Monroe, Mich.
Carl G. Krancher, Ball Bros. Co., Noblesville, Ind.
John Knoll, Monroe Falls Paper Co., Monroe Falls, Ohio
J. Melvin Kernan, Ohio Boxboard Co., Rittman, Ohio
P. J. McDowell, A. L. Garber Co., Cleveland, Ohio
Milton Hasselo, Hasselo Cigar Box Co., Cleveland, Ohio

Following the election there was a symposium on "Paper and Paperboard Finishes." E. E. Thomas of Appleton Machine Co., Appleton, Wis., presented the machine builders viewpoint and gave a clear presentation of the mechanical means of obtaining finishes with calenders and supercalenders.

P. C. Plehn of the Consolidated Paper Co., Monroe, Mich., gave the paperboard makers viewpoint. Mr. Plehn's remarks follow:

THE PAPERMAKER'S VIEWPOINT ON FINISH

"A good finish is the ultimate goal toward which the papermaker is constantly working, especially so when he is making folding box board or container board for printing. He bases his entire production setup on the type of surface desired on a particular sheet. Mills making the same types of boards are basically the same in that they use similar kinds of raw stock, refining equipment, paper-machine equipment and calender equipment, but that is about as far as the comparison can be carried. What the papermaker does with his equipment determines the quality of his product. He must keep in mind that almost anything he does to make paper will affect the finish and any changes made will ultimately affect the surface characteristics. In the production of paperboard this is probably more intensified because of the relatively heavier sheet and the many factors which are involved, other than surface characteristics—such as density, bending qualities, splitting, moisture content, etc.

"There are many factors affecting the finish on paperboard. The type of fiber furnish, the stock preparation equipment, chemical additions to the stock, stock characteristics on the paper machine, the paper machine itself and its water removal system, the drying, and, finally, the calendering operation.

"The type of fiber used in a particular sheet may vary over wide ranges and the different refining and processing characteristics must be taken into account. Kraft pulp would require more power and more refining than sulphite, soda or groundwood. The balance between the various types of pulp and waste papers which are used in a furnish to attain such things as color, brightness, folding, etc., and their operating characteristics, when they are put together into a sheet on the paper machine must constantly be watched or quality and production will suffer. For instance, a No. 1 white patent coated sheet would probably contain bleached kraft or bleached sulphite, hard white shavings, and possibly some bleached soda pulp in the top liner. The underliner may have, say, unbleached sulphite, groundwood, and possibly some uncolored flyleaf cuttings or deinked stock. The filler would contain various types of broke found in the mill, possibly some news and some kraft in the form of corrugated or kraft waste and probably some of the general run of chip. The back liner would probably be news with some corrugated if a news back or something similar to the top or underliner if a manila back. All of these types of fiber must be so processed that they will run together on the machine to make a sheet of the desired finish, density, folding qualities, brightness, moisture content, etc.

"The stock preparation equipment affects the finish by the type of equipment and the amount of equipment or power available. A heavy, all kraft or other strong furnish sheet could not be run economically on a machine designed to run a lightweight bleached manila or white boxboard. The beater and the jordan are the old standbys of the paper mill, but in recent years they are gradually being supplanted by higher capacity and more efficient machines, such as the Hydrapulper, Dynopulper, Hydrafiner, Dynopeller in chest, etc. There are a host of such machines. The type of refining equipment will depend to some extent on just how good or what kind of finish is required. In other words, the economic aspect of the over-all picture has to be kept in mind. The mill may not be trying to make a super high-quality, high-finish board which would almost be considered a specialty, but may be content to produce a medium quality board selling in greater volume.

"In considering stock preparation equipment, the type and efficiency of the dirt and trash removal equipment must be considered, particularly in connection with waste paper and chip. In the older beater systems, a dry method of junk removal is used with large revolving perforated drums or dusters. In a wet system of handling the stock in a Hydrapulper or Dynopulper, the waste, as is, is dumped into the machine and the junk and trash is removed by settling and junk removers. This is more efficient in removal of unwanted material which could cause trouble in the sheet by producing lumps and foreign spots which would greatly affect the finish.

"The efficiency of rotary or shaking screens over flat screens for screening the stock previous to putting it on the paper machine is another factor affecting finish.

"The chemical additions to the stock are of primary importance to the production of good finish. These include filling, sizing, chemical additions for densifying, and for producing high finishes. The filler additions include clay, talc, calcium carbonate, diatomaceous materials, and a few others. These materials can be added simply to help tighten the sheet by filling the voids between fibers, with only a relatively small amount, or they can be used in amounts of 25 to 30% to produce a sheet which has almost the smoothness and printing quality of a clay coated sheet. This applies particularly to the diatomaceous materials, which have the least tendency to slow drainage on the paper machine in large amounts and actually help drainage when used in moderate amounts.

"Starch sizing in the beater is one of the most common methods of improving the finish. It tightens the sheet and tends to cement the fibers together and allows them to be tightly packed together to make a slick, glossy, sheet. Larger amounts of starch used throughout the sheet tend to make a hard, snappy, sheet and in conjunction with filler to make a sheet of very good printing quality.

"Rosin size affects the finish somewhat indirectly in that its use tends to prevent water penetration at the calender when using calender sizes. It also, in conjunction with starch, tends to make the surface harder and more scuff-resistant and less liable to pick on the calender and on printing presses. If the sheet is to be combined in a pasting operation to make solid fiber container board, rosin sizing is used to hinder penetration of water-borne adhesives into the board and give more efficient spread. However, this can be carried to only a limited degree or trouble will be encountered on the paster and the sheets will tend to be slow in initially combining off the end of the paster and production will be lost. A balance must be maintained between degree of water penetration, thinness of glue line, and initial tack. Asphalt, as an emulsion or clay suspension, can also be used for sizing but is usually confined to the filler and then only in dark or black boards, as

(continued on page 70 A)

Facsimile of the first-known Christmas Greeting Card. Original now on display in the British Museum in London.

The First Christmas Card

When, in 1842, William Maw Egley, a young London engraver's apprentice, produced the first-known Christmas card, he started what was destined to become both a popular custom and a major industry. While the Christmas card originated in England, the sending and receiving of greeting cards has attained its greatest popularity in America. Today more than two hundred greeting card publishers produce more than three billion cards annually. It is estimated that nearly one hundred million dollars is now spent each year to mail greeting cards of all types and for all occasions—a sum representing approximately ten percent of the Government's first-class mail revenue.

In reaching such a vast volume, greeting cards have become one of the largest users of paper, and thus have made an important contribution to the swift, continuous growth of America's pulp and paper industry.

The dramatic story of paper is told in the sound-and-color film, "Paper — Pacemaker of Progress," and in a book under the same title. Both are presented by F. C. Huyck & Sons as a tribute to the Paper Industry. The book will be sent free upon request.

F. C. HUYCK & SONS • *Kenwood Mills* • RENSSELAER, N. Y.

KENWOOD WOOL PRODUCTS

HUYCK *Felts*

(continued from page 68 A)

for instance, beer-case stock or black automotive panel-board. It does not enter into a discussion of finish particularly, because it tends to bleed out on the driers and foul them with asphalt, if used in the top liner.

"Any chemical additions, in general, tend to impair to some extent the operating characteristics, i.e., the rate of drainage and the type and amount of pressing of the stock on the paper machine and a balance has to be maintained between the quality desired, the drainage on the machine, the speed of production, and the type of equipment for finishing.

"The stock-characteristics on the paper machine affect the finish in a number of ways. If the rate of drainage or freeness is too high, poor formation results, i.e., the fibers do not have time to lay down in a good pattern before the water has drained away. This may result in a spotty, mottled sheet appearance and give a very rough, uneven surface. Too-free stock also gives poor bonding of consecutive layers laid down from the vat cylinders. This results in splitting or blowing and may give picking of the surface on the calenders, or later during the converting operation on the printing press. Too-slow stock or one with a low drainage rate produces a soggy mass on the wire from which it is difficult to drive the water in the paper machine presses. This makes it necessary to run slower to allow time for drainage, other factors being equal. The freeness must be balanced between the different types of stock run on the various cylinders. If the liner is much slower to drain than the filler or underliner, then the water cannot get away and blowing or ply-separation results. A great deal of skill and "know-how" are required when trouble is encountered to know just what to do, i.e., to slow down the filler or free the liner or make other adjustments.

"There are a great many paper machine characteristics affecting finish, among them are the type of wire (coarse mesh or fine mesh), type and weave of the felts used and the type of water removal equipment. In regard to the wire, a coarse wire, of course, gives better drainage, but it also makes a distinct pattern of wire marks on the surface which are practically impossible to remove. A fine wire produces just the opposite effect and the problem again resolves itself into the economic consideration of just what is desired. The character of the weave of the felt has some bearing on finish but not as much as the wire. Probably more important is the faculty of the felt to conduct water and its tendency to either fill up quickly or stay open for a long period.

"The water removal equipment or press section on a paper machine can make or break the sheet, both figuratively and actually. There are many types of presses but perhaps the most common are the plain extractor roll, the suction extractor roll, the suction return roll, the baby press, the suction press, the primary press, and the smoothing press. The extractor rolls are used to remove water from the formed stock while it is in contact with the felt and the press rolls are mainly used to remove the marks put in the sheet on the cylinders and the extractor rolls. The extractors are wire-covered rolls with a couch roll which can be weighted or unweighted. Weighting can be deleterious to the finish, especially when the sheet is single felted through the extractors, because the sheet is forced into the wire to a greater extent. Light weighting removes less water at this point, keeps wire marks to a minimum and keeps the sheet more plastic for further treatment in the primary presses to remove wire marks and felt marks. The suction extractor roll is more efficient in water removal after the sheet has gone through a plain press and had a good deal of the water removed. A suction return roll, which consists of a wire covered roll on which the felt wraps on its way to the dry end of the machine and which may be couched or uncouched, should be more efficient in water removal and cause less marking of the sheet than either a plain extractor or a suction extractor. The sheet does not come in contact with the wire but has a long period of contact with the roll. When a couch roll is used, a top felt must also be used. The baby-press function is to remove more water and to harden the sheet preparatory to primary pressing. The sheet is felted (top and bottom) through these rolls. The suction press has about the same function as the baby press but is somewhat more efficient in water removal. The primary press is used to smooth the sheet and remove felt and wire marks. This is a polished brass roll and the sheet is felted on the bottom only. It is usually weighted to give better results. The smoothing press consists of one polished brass roll and one rubber roll used just before the driers. The sheet is fed through unfelted to help remove wire and felt marks. The sheet at this point must be dry and hard enough to stand this bare pressing or it will rupture and cause blowing and crushing.

"The drying operation can affect finish in a number of ways. Among these are the condition of the drier rolls, the abrupt flashing of water from the sheet and the degree of drying before more smoothing or sizing operations take place.

"It is obvious to anyone that the driers should be clean and free of bumps and projections to make the highest finish sheet. When the sheet first enters the drier rolls it has been prepared by the presses to give the best possible surface with the equipment available and as it is very tender and easily disrupted at this point, any projections from the surface of the rolls will tend to stretch the sheet at that point and leave a mark or pocket after calendering.

"If the sheet has been well made and balanced as far as good drainage is concerned, on the machine, there will not be much trouble encountered on the driers in regard to flashing out water. Occasionally, blowing may result on the driers if the inner layers are too highly hydrated and the surface is tight and hard, but this will usually show up on the machine itself. In running board with an asphalt film between the plies, this film should be put as close to the center of the sheet as possible, as uneven drying may result because the asphalt will prevent water removal through the sheet and it must dry nearly equally from each side.

"As was mentioned before, under machine pressing, the papermaker can do more for this sheet in regard to finishing if the sheet is soft and plastic and still has the ability to flow under pressure. Only a limited amount of this flow or movement can be accomplished on the machine itself through pressing and smoothing rolls because the sheet is so tender that it would crush and be disrupted if higher pressures were applied. However, if additional smoothing equipment is used after the sheet has been partially dried and is not so tender, then greater pressures can be used. Some mills are using a breaker stack in the driers after the sheet has been dried down to a point where greater weights can be used. This usually consists of one or two nips about half or three-quarters of the way through the driers, and then finishing drying of the sheet to a point where it can take the high pressures of the regular calendar stack.

"Additional finishing can be secured if a size press is used to flood the sheet with a material to cement the fibers down and tighten the surface by closing the voids between fibers. This is applied after the sheet is partially dried in order to secure some subsurface penetration into the body of the sheet and can be used in conjunction with a breaker stack or alone. Starch, casein and some of the natural and synthetic gums among other materials are used for this purpose. At this point, also, a coating station is used frequently to put a light pigment coating on the sheet, i.e., the so-called 'machine coating.' This produces a sheet with a very smooth finish and good printing qualities and also improves the brightness depending on the brightness of the pigments used. However, it requires that a good smooth sheet with a minimum of felt and wire marks and of initial good brightness be produced before it can be coated in this manner or a mottled sheet will result.

"Moisture content of a sheet as it enters the driers is indirectly very important to finish and printability, particularly from the standpoint of cockle and shrinkage. A finished sheet with too high moisture will cause trouble from misregister in printing, cutting, and folding, particularly if there is much delay between these various operations. As the calender cannot function properly to produce a slick surface unless the fibers are damp and compressible, it is necessary to add water at the calender rolls to achieve this. Consequently, the sheet must be almost bone-dry when entering the calenders or the total moisture-pickup will be excessive. The calender tends to produce a sidewise curl in the sheet by stretching the surface fibers particularly if only one side is wet; therefore, both sides of the sheet must be treated and a balance maintained to reduce this tendency.

"Although water is the most common calender finishing material, there are many other products on the market which are used to effect special results. It is a convenient place to add surface treating chemicals economically and efficiently. Various sizing materials for gloss ink printing are added here to seal the sheet against the penetration of the ink oils and varnishes. Starch is commonly used to give a generally good finish. It is possible to use the calender boxes to add pigment suspensions to the surface to achieve good printability, and, in a measure, to increase the brightness. However, unless the surface is very smooth and free of wire and felt marks, this will produce a mottled sheet because more pigment will remain in the low spots as the sheet passes through the calender-nip and the high spots will be wiped clean.

"In general, then, it can be seen that the finish on the sheet is a complex quality which is the result of a coordination of many factors, some of which are readily controllable while others require constant vigilance on the part

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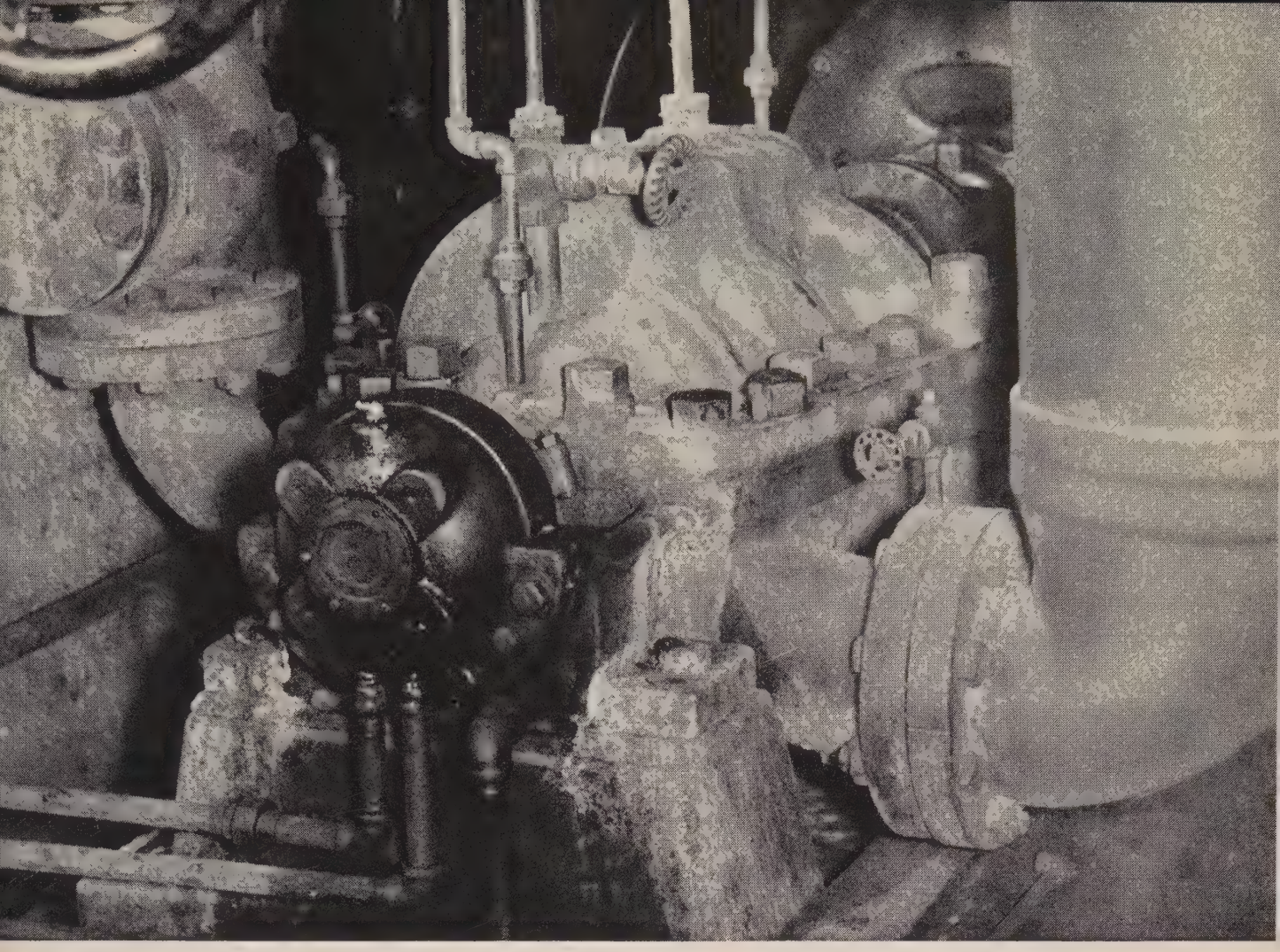


Pump puts the "heat" on grease

HEAT from the shaft of the boiler feed pump shown above kept a conventional grease in plenty of trouble. The severe conditions caused the grease to oxidize and gum up on the pump's ball bearings. Consequently, the bearings overheated. Grease had to be applied every few hours. The pump had to be shut down frequently so that the bearings could be cleaned.

Officials of this plant put their problem to a Standard Oil Lubrication Engineer. The Engineer recommended Stanolith Grease No. 57, a lithium-soap product with the unique ability to withstand both heat and water.

On the bearings, Stanolith stood up under the high temperatures. It would also resist any water washing should leaks develop. Over-heating troubles were stopped. Downtime was eliminated. Instead of the previous daily greasings, only one application of Stanolith was required each week—an important saving of both lubricant and labor.

Lubrication problems caused by heat, water, or low temperatures in your plant can be solved by this *one* lubricant: Stanolith Grease. Through its remarkable versatility, you can avoid the cost and trouble of stocking and using a variety of special greases. A Standard Oil Lubrication Engineer will help you make these savings.

Write Standard Oil Company (Indiana), 910 South Michigan Avenue, Chicago 80, Illinois.

PROBLEM SOLVED BY...

Stanolith Grease

ANDARD OIL COMPANY (INDIANA) STANDARD

(continued from page 70A)

of the papermaker to make his sheet run well on the machine and produce the quality he desires."

The third speaker was K. B. Latimer, who is associated with Paul J. Thoma, Consultant for Time, Inc., Mr. Latimer's remarks follow:

PREDETERMINING PRINTABILITY

"Gentlemen: I must ask your indulgence in accepting me as a substitute for Mr. Thoma. He could do much more with the subject of paper and paperboard finishes than I can. The title of this paper might well be 'Predetermining Printability' and I should like to treat this subject particularly from the testing angle of a paper user. Predetermining the operability of plates, paper, ink presses, and the like is a subject of great interest to Time Inc.

"In our research setup at Time Inc. we have an opportunity which, to my knowledge, does not exist anywhere else, where the press designer, ink formulator, and paper coater can interchange ideas and be of mutal assistance in producing printing at ultra-high speeds yet with maximum quality.

"In dealing with our numerous suppliers we are continually faced with the problem of judging the quality and value of their product. Since the quality and cost of a printed piece is dependent on many factors such as paper, ink, plates, presses and the skill of the printer it is difficult for a company like Time Inc. to lay its finger on the particular factor causing poor quality or excessive cost. Furthermore, with our extensive research program we have the problem of evaluating numerous new ideas and developments. Until recently we also had the problem of maintaining the desired quality in paper for Life magazine, coated in our own mill.

"Much of the knowledge we gained in attempting to find the answers to these problems of evaluation came the hard way through the operation of the coating mill. A great deal has been written about paper, on the subject of what is required to make a good printing sheet. Without getting too much involved, I think it is fairly well agreed that for letter press printing, what is needed is a paper that is smooth—and that will accept ink readily but not act like a blotter and let all the ink sink in—one that is resilient and will compress and take up at least a part of the irregularity in plate surface and yet one that will spring back to somewhere near its original caliper for subsequent color applications. Several books could be written on the subject but the meat is fairly well contained in these specifications.

"Let us look at smoothness first. We have taken a page from the books of the metal industry and are using in the laboratory a Brush Surface Analyzer as a measurement of true smoothness. This is an instrument that has a sensitive stylus that runs over the surface of the sheet and then magnifies and records the hills and valleys in the paper surface. It also has a device that indicates the average variation between these hills and valleys. By checking the smoothness in this fashion of many rolls produced in our own coating mill and following their printing performance at our printers, we have defined at least in part the range of smoothness required to get good coverage. To double check ourselves at this point and in an attempt to eliminate some of the variables, when dealing with our mill production, we made daily checks of a number of rolls by taking strips from each of these rolls, mounting them on a single backing sheet, and underlaying them to get positive caliper control and then pulling a single proof on the proof press. In this fashion we minimized the effect of variation in impression, amount of ink carried, plate surface, etc. From observing hundreds of tests of this type, we found that we get good coverage when we have an average smoothness somewhere in the range of 70 to 80 as measured by the Brush Surface Analyzer. Bear in mind that this presupposes that the ink-receptivity and resilience are somewhere near comparable. From these studies, we are of the opinion that smoothness probably is the most important factor for good quality and we feel that this can be predetermined to a large degree by the use of an instrument like the Brush.

"All of our suppliers' papers have improved in smoothness over a period of three years and we are becoming more critical all the time. We occasionally find sheets with tiny pits on the surface that affect the printed result and produce a grayed-out appearance. These pits are not indicated by Brush readings and so we are presently trying various sizes of stylus to get down into the pits and show them on the chart. The electronic group in our research laboratory is also investigating the possibility of measuring smoothness by the use of ultrasonics.

"The next factor, ink receptivity, is a tough one too. Frankly, we have not as yet been able to satisfy ourselves that we have a definite method of pinning down the limits within which we must operate to get a good quality printing. We do know this much. If we have a sheet that is smooth and has very high ink receptivity so that the ink strikes into the coated surface with great rapidity, we generally expect to get poor printing results. The solid areas look gray and in some cases actually look broken, and the halftones dots themselves appear to lack good uniform coverage, If we curtail this penetration of the ink into the coated surface by any one of three or four methods, such as increase of the binder in our coating, the use of additives such as stearates, waxes and the like, or by increasing the amount of calendering, we find that our printing improves up to a point. When we get to the other part of the spectrum and have a sheet with a very hard surface that resists ink, we run into another problem. The trap of the ink is effected materially. Apparently the first down color or colors do not drop their vehicle into the sheet and present a dry surface for taking the subsequent colors, and instead of having good oranges, greens, purples, and browns, they tend to become very muddy. Normally, it is the practice at this point to really put the heat on the ink maker, but actually it isn't his problem at all. It is strictly the paper man's problem to get a surface that will accept ink properly. In addition, the drying speed of the ink is reduced materially as we get to the higher range of resistance to absorption. Under some tests that we have run on our laboratory press, we have found that ink drying speeds can be reduced 25 to 30 per cent merely by altering the surface characteristics of the coating in the sheet of paper.

"The ink receptivity of the sheet also has a material effect on the ability of the ink to run clean and not plug halftones or pile in the solid areas. It is our opinion that in a number of cases, plates and inks have been condemned when it is really a paper problem.

"Ink makers are all familiar with the phenomena on a proving press where the same ink is used to print several different sheets. By examining the plate after each impression there is a marked difference in the residue of ink remaining on the plate after the printing cycle. Where the sheet refuses to accept ink properly it is our firm belief that this can be traced as a positive source of pile and fill. Naturally, the pressman's first reaction is to say that the plates are shallow and have not been etched deep enough or the ink maker has failed to perform satisfactorily and has sent a batch of ink over that is not up to standard. As I mentioned a few moments ago, we have not as yet solved the problem of how to set up a laboratory method to predetermine the limits of ink receptivity. However, we think such a controlling device can eventually be put together which will certainly work to the advantage of all people concerned.

"Another point that is receiving some of our attention is the question of resilience of a sheet of paper. As you gentlemen all know, the conventional practice in the paper industry at the present time in making coated paper is to make the paper stock, coat it with a mixture of mineral pigments such as clay, calcium carbonate, etc., and bind these to the surface of the fiber based structure with binders such as starch, casein, soya bean protein, and the like After this operation, the sheet goes through a calender stack where an ironing operation is performed to obtain smoothness, etc. This calendering or ironing operation plays a very important part in the physical aspects of the sheet. Smoothness, for example, is promoted to a degree. The glare or finish is largely obtained here and the control of ink penetration is effected very materially. In addition, this ironing operation is responsible for the final caliper obtained and can change the amount of resilience left in the paper. You will note that I very carefully avoided saying that it does do this or it does do that, because other factors such as the type of coating material, type of raw stock, moisture in the sheet, all play a very important part in what happens in the calendering operation. The problem of how best to obtain smoothness, correct ink receptivity, and yet retain maximum resilience is a tough one. In order to test this latter point, we had a gadget built for our use which utilizes a micrometer calibrated in tenths of thousandths of an inch. The instrument has a pair of anvils an eighth of an inch wide and one inch long. We can put a sheet of paper between these anvils and measure the thickness at no load; in other words, what its normal caliper might be. We are then able to put pressure on the small anvils up to about 250 pounds. Thus we approximate, if you will, the pressure that takes place at the nip between the plate cylinder and impression cylinder during the printing cycle. We have had to assume of course that the normal land is $^1/_8$ of an inch wide, and we realize that this is dependent on the type of packing, type of press, etc. However, in discussing the problem with a number of press manufacturers,

(continued on page 74A)

MANY TYPES OF CHIKSAN SWIVEL JOINTS FOR PAPER MILL SERVICE

25 Years of Experience in the Manufacture of Ball-Bearing Swivel Joints assures dependable Operation and Long Life.

With the development of Chiksan High Temperature Rotating Joints and High Temperature Swivel Joints (Metallic Seal), Chiksan can supply every type of Swivel Joint required in the manufacture of paper and paper products—from pulp to finished products. Over 500 different Types, Styles and Sizes are produced in addition to those shown on the right. Pressure capacities range from 125 psi. for aluminum Joints to 15,000 psi. for forged steel Joints. Sizes run from 3/8" to 12". Temperature range is from −40° F. to 600° F.

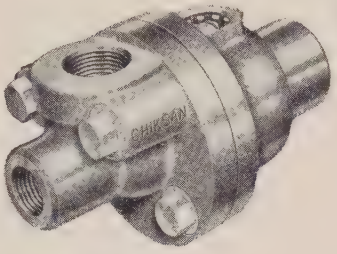
Since unlimited flexibility in any line is possible merely by arranging swivels in proper sequence, the greater safety and longer life of steel makes for greater economy than is attainable through the use of other types of flexible hose.

Chiksan Swivel Joints are used in the Paper Industry for handling highly corrosive liquors, water, steam and other fluids. With the Chiksan High Temperature Rotating Joint, new standards of performance can be achieved in the operation of dryer rolls, calenders, corrugating rolls and other rotating equipment. The positive seal eliminates all stuffing boxes and permits the unit to rotate freely with minimum torque, thus decreasing the load on the driving unit.

Chiksan's Engineering Department is available at all times for assistance in developing installations which will assure maximum efficiency in operation and satisfaction to the user. In addition to this service, which is free of charge, trained field representatives are also available for consultation in your own plant. An inquiry entails no obligation of any kind.

DESIGNED TO SAVE *You* MONEY!

After several years of research and development, CHIKSAN is now ready with two new types of High Temperature Joints which represent the latest in design and performance. They are built specifically to answer the many problems encountered in the handling of steam and other high temperature fluids on rotating equipment and in flexible lines.

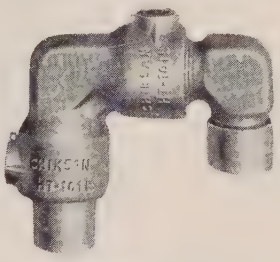


Maximum Working Pressure—150 lbs. steam.
1", 1½" and 2" sizes now available. Other sizes under development.
Cadmium Plated Chrome Seal Face.
Rotating speeds, 150 to 300 R.P.M.
Built to serve. Built to last.

NOW!

CHIKSAN HIGH TEMPERATURE ROTATING JOINTS

Designed and built for use on rotating drums, platens, tumblers, etc. This new Rotating Joint will handle steam, hot oil, water, brine, etc. Rotation may be constant or intermittent. The service may be hot or cold. A positive seal prevents leakage at all times. Packing chamber is hard-chrome plated. All parts are resistant to rust and corrosion.



Made in 8 different styles for turning in 1, 2 and 3 planes.
1", 1½" and 2" sizes now available. Other sizes under development.
Positive Metallic Seal.
Maximum working pressure 300 psi.
Maximum temperature, 600° F.

NOW!

CHIKSAN HIGH TEMPERATURE SWIVEL JOINTS (Metallic Seal)

These new Joints set new performance standards wherever steam or other hot fluids are handled through flexible lines. The Metallic Seal provides positive protection against leaks. Full 360° turning on stainless steel ball bearings which help to absorb radial and thrust loads. Unlimited flexibility is possible simply by arranging the swivels in proper sequence.

COMPLETE ENGINEERING DATA

Write for illustrated bulletins and see for yourself how these new CHIKSAN Joints can help you cut leakage losses, operating and maintenance costs, and shut-down time now required for frequent repairs and replacements.

REPRESENTATIVES IN PRINCIPAL CITIES

CHIKSAN
TRADE MARK REG.

CHIKSAN COMPANY
AND SUBSIDIARY COMPANIES
Chicago 3 · BREA, CALIFORNIA · New York 7
WELL EQUIPMENT MFG. CORP. HOUSTON 1, TEXAS
CHIKSAN EXPORT CO. BREA, CALIFORNIA · NEW YORK 7

BALL-BEARING SWIVEL JOINTS FOR ALL PURPOSES

(continued from page 72 A)

they indicated that 200 pounds of pressure per inch on a strip about 1/8 inch wide was probably as good an approximation of what normal press operation would be as we could get, and we have set up our instrument on that basis. With 200 pounds pressure, we can again measure the caliper. We then remove the pressure and measure the caliper between the two anvil faces with the load off. As you can see, we can obtain these figures. We know the original caliper, we know the amount which the paper compresses under a given load and we know the amount of spring back or regain in caliper when that load is removed. Again, I cannot say that we know how to interpret our results as yet but at least we think that we can obtain enough data and correlate it with actual printing results so that some day we can set up limits that will indicate how much resilience we need in a sheet of paper for good multicolor printing.

"Another interesting point on the quality of heat set multicolor rotary printing is the effect of moisture. If the sheet lacks sufficient moisture, and frankly we don't know just exactly what this lower limit is, the paper tends to become very brittle and abrupt changes of tension on the press or small edge cracks in the sheet will cause web breaks and excess down time on the press. On the other hand, if the moisture in the sheet is too high or if the surface of the sheet of coated paper is sealed over by the type of coating used or the amount of calendering that the sheet is given, the sheet will blister when it goes through one of the ink driers. Actually, for those of you who are not familiar with this phenomena, the sheet will come out looking as though it had water blisters all over it—the type you would get if you would put your finger on the top of a hot stove. This phenomena is exaggerated where there is a heavy solid of ink printed back to back on both sides of the sheet, but if the moisture is high and the coating tends to seal it in, the sheet will blister on the unprinted areas as well. We are getting much closer to the control limit on the problem and it is our feeling at the present time that if moisture ranges are kept somewhere between 4.5 and 5.5 per cent no trouble will be encountered. However, this is only a partial solution to the problem and we are still working on it trying to tie down these limitations rather exactly.

"Paper moisture is of extreme interest to the inkmaker as well as the printer and papermaker. We have found that as the moisture increases upward of 5 to 6 per cent it has a very marked effect on the drying speed of the ink. We ran a rather interesting experiment at Donnelley's, for example, which certainly brought this point out very well indeed. We made up a roll of paper wherein we kept factors such as raw stock, coat weight, type of coating, amount of calendering, and what have you, as consistent as we possibly could. We deliberately varied the moisture in various portions of this roll and marked them plainly to see what effect they would have on printability. One of the most marked differences that we noticed was the fact that the ink-drying speed was materially slowed when the moisture was 6.5 or 7 per cent. As a matter of fact, at 7 per cent moisture it was necessary for us to slow the press down to 75 per cent of its full speed using the full capacity of the gas drier in order to get the ink to dry. We noticed at the same time, of course, some effect from blistering, etc. which would be normal in sheets with such a high-moisture content. This, of course, is a little off the subject but we do feel that predetermination of moisture is something that should be studied.

"And now a few words about our efforts to do the same job on ink that we are attempting on paper. We have carried out numerous ink evaluation tests on our high speed 17-inch laboratory press. This press will run up to 1500 feet per minute and is equipped with a modern Selas gas drier that will dry conventional heat-set inks up to that speed. It is equipped with instrumentation which allows us to measure the gas input required to dry various types of inks and can be used to check two colors on one side with a full web or by use of a half-web and turning bars can check two colors on each side or four colors on one side.

"It is easy to see what this means in terms of checking printability of paper and ink. As an example, we have spent considerable time with one of our ink suppliers over the past few months in evaluating the inks that they are producing in comparison with those produced in R. R. Donnelley's private ink plant. By careful examination of the trap sequence between each two colors, for example, blue and black, we were able to point out that the supplier's ink did not trap properly under actual operating conditions. We found this lack of trap to be particularly bad at elevated press temperatures such as are encountered in summer operation. To approximate this condition we heated the inking system by running hot water through the steel distributor rolls and operated the ink carriage backed off from the impression cylinder until the entire system reached 135 to 140°F.

"After getting the press up to operating temperature we then checked the trap sequence between a number of blue and black inks. We were able to hold press conditions very uniform and the demonstration was very convincing inasmuch as all the inks were formulated to trap, yet only one set of colors out of 8 or 10 was found to meet the R. R. Donnelley standard. I might add with regard to my statement that the inks were formulated to trap, that normal ink checking devices such as an inkometer were used in making these determinations, yet strangely enough the ability to trap properly could not be detected except on the press.

"On the basis of this work it appears that Time Inc. has a very valuable tool in the laboratory press that can be used to demonstrate quality deficiencies to both inkmakers and printers when our color control people get into an argument over the difficulties they are having with some job.

"We have an ink today, pretested on the laboratory press which we ran for better than 15 months on one press, that requires 40 per cent less heat to dry than conventional inks. We finally threw it out because it did not go far enough. What we really require is an ink which will dry without any heat or at least with such a low amount of heat that when dried we will still have 3.5 to 4 per cent moisture in the paper after drying. By the use of such an ink we would save a tremendous sum in paper costs. Present ink driers degrade our paper strength by at least 20 per cent and we are forced to use a costlier furnish to take care of this loss in strength.

"The ink manufacturer has always been decidedly limited as to the percentage of pigment in his inks because of the narrow range of ink bodies that the distribution system on the presses would handle at high speeds. At the same time, he had to adjust the tack, penetration and body of his inks to fit the particular requirements of the coating that the paper manufacturer furnished.

"The experimental engineering department at our laboratory is developing a new ink distribution system that we hope will handle highly pigmented—heavy bodied, low boiling solvent type inks by cutting down about 50 per cent of the distance the ink has to travel from fountain to plate. Inks of this type would offer serveral advantages.

"Actually, our thinking boils down to this—if we can successfully use a heavy-bodied ink we can cut down the amount of solvent that must be driven off from an ink film of any given thickness. For example, one of the present heat-drying blacks furnished by a large ink company for Life has roughly 20 per cent of pigment, 45 per cent of resins, plasticisers, waxes and so forth and 35 per cent of solvent. We have found that with an improved ink distribution system we can formulate an ink with 30 per cent of pigment, 40 per cent of resins, plasticisers, etc., and 30 per cent of solvent. Thus for any given thickness of ink film deposited on a sheet of paper we have roughly 5 per cent less solvent to drive off.

"This represents only part of the picture. As we increase the pigment concentration we can attain comparable color strength in a print with a thinner film of ink. Here again, as we reduce film thickness, we reduce the amount of solvent that has to be driven off.

"Printing thin ink films using heavy-bodied inks offers several other advantages. In the first place, the quality of the printing, theoretically, will improve in almost a direct ratio with the increase in body of the ink and the thinness of the film. What an inkmaker would like to be able to make, is an ink that is free flowing, will follow the fountain readily, and distribute easily up to a point where it is applied to the plate. Here he would like to wave a magic wand and change the free flowing ink into a thick viscous jell that would stay on the top of each halftone dot and not spread or squash when it was transferred to the paper.

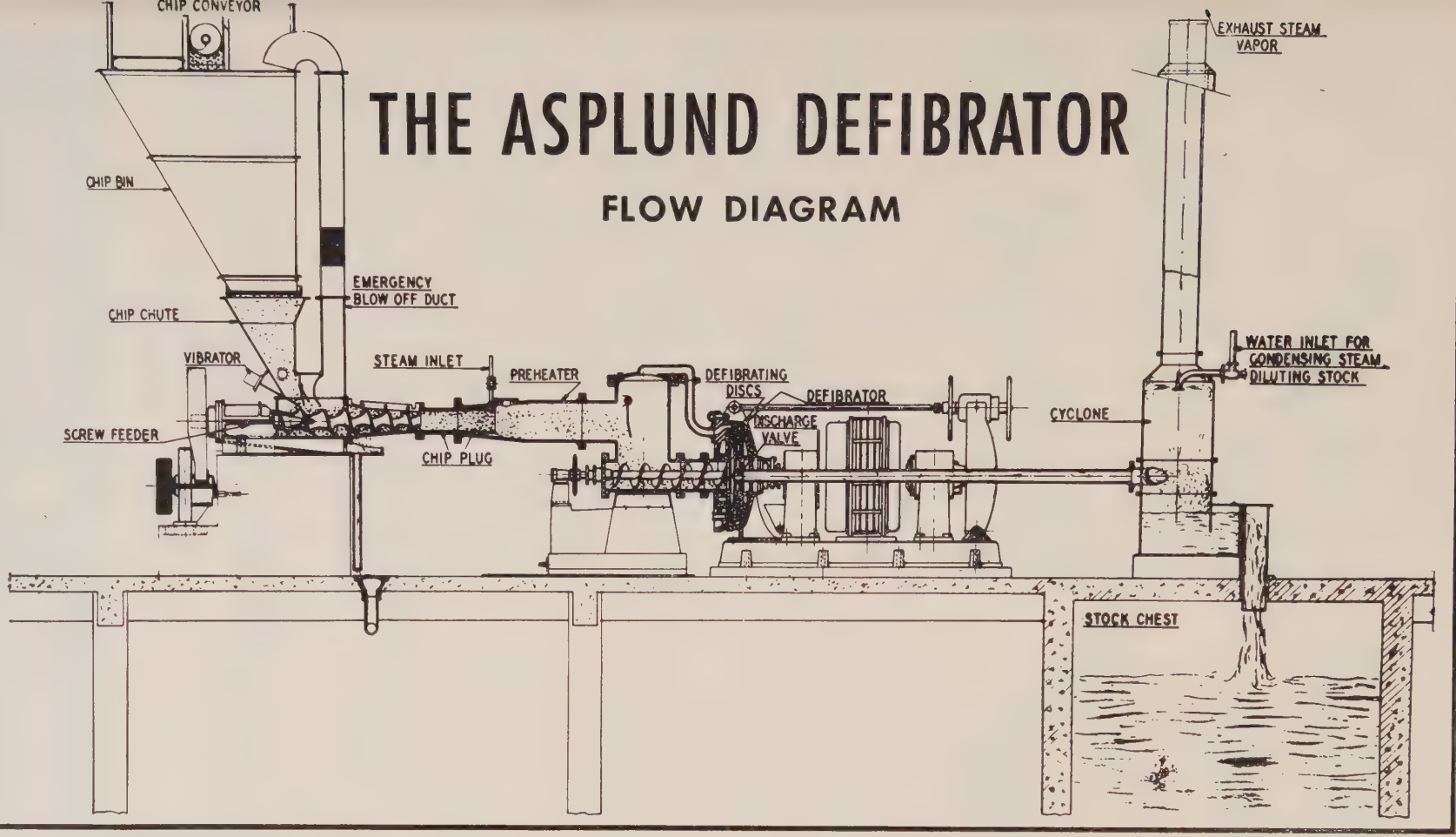
"Low-boiling solvents and fewer rollers in the distribution system may help this problem. Low boiling solvents will flash off at a lower temperature, of course. The ink distribution system we are working on will have fewer rollers. We have also done some work with rollers that indicate that aromatic type solvents with K.B. values up to 75 and 100 can be used without too much trouble.

"Unfortunately, you cannot have your cake and eat it too. Up to this time we have had to compromise and make inks that are actually somewhere between the two extremes. The inkmaker still cannot overload pigment into his formulation because the body of the ink becomes too heavy to distribute well at high speeds so again he compromises and the printer is forced in some cases to carry excess ink in order to get sufficient color value to reproduce the subject.

(continued on page 76 A)

THE ASPLUND DEFIBRATOR

FLOW DIAGRAM



In one continuous, economical process, the Asplund Defibrator produces pulp for wallboard, hardboard, insulating board and roofing felt—from all kinds of chipped wood, or from other fibrous ligno-cellulose materials such as bagasse or straw.

Asplund pulp is homogeneous and free, with individual fibres intact but well separated, and it has good felting properties. The yield is high, and production costs are low. Technical advice on defibration is available without obligation.

AMERICAN DEFIBRATOR, INC.

HEADQUARTERS:
CHRYSLER BUILDING
NEW YORK 17, N. Y.

WEST COAST:
A. H. Lundberg
Orpheum Building
Seattle, Washington

(continued from page 74A)

Unfortunately, just 'ladeling on' ink does not solve the problem because drying speed is effected, the form starts to fill in and quality usually drops off.

"All of this merely represents some of the advantages we believe will accrue with the use of highly pigmented low-boiling solvent inks.

"In a long range research program we are endeavoring to find out the best possible results that can be obtained in four color work. By using papers varying from dull to very glossy and inks varying from standard heat set to high-gloss inks we have obtained a series of four color proofs that show the wide variation in appearance that can result from various combinations. If we could get a dull paper with sufficient smoothness and the low receptivity of a glossy paper and print it with high-gloss inks that will stay on top we might have a combination which would be particularly attractive."

Delaware Valley

The Delaware Valley Section met at York, Pa., on October 7. The afternoon was devoted to visiting the P. H. Glatfelter Co. mill at Spring Grove, Pa. About 150 attended. Following the dinner Charles Adams and G. A. Peterson of the Rice Barton Corp., Worcester, Mass., gave a summary of "Some New Developments on Paper Machines."

John P. Weidner, Chairman of the Section introduced F. J. Lovegren of W. C. Hamilton & Sons and H. C. Brill of DuPont who were appointed Secretary and Treasurer of the Section, succeeding Miss Lois Hans who has gone to Northern New York.

On October 27 A. J. Pingarron of the International Printing Ink Co., New York, N. Y., gave a talk on "End Use as a Factor in Ink Formulation."

The next meeting will be held at the Engineers Club in Philadelphia on November 30. Simon Collier of the Johns-Manville Corp., will talk on "Modern Quality Control."

Pacific

The Pacific Section met at the Towers, Tacoma, Wash., on October 25. L. F. Maybach, Crown Zellerbach Corp., Camas, Wash., presided as program chairman. A group of papers on "Instrumentation" were presented. These included:

"Electronics in the Paper Industry," by Fred Thompson, General Electric Co., Seattle, Wash.

"pH Control on Paper Machines," by Howard C. Hall, Crown Zellerbach Corp., Camas, Wash.

"Basis Weight Control on Paper Machines," by Wallace Sawyer, Portland, Ore.

"Consistency Control Using the Photoelectric Cell," by H. T. Peterson, Pulp Div., Weyerhaeuser Timber Co., Longview, Wash.

"Sulphur Level Control in Rotary Sulphur Burners," by Forrest Williams, Crown Zellerbach Corp., Camas, Wash.

"Measurement and Control of Chlorine," by Brian L. Shera, Pennsylvania Salt Mfg. Co., of Washington, Tacoma, Wash.

The dinner speaker was Howard W. Morgan, Pulp Div., Weyerhaeuser Timber Co., Tacoma, Wash.

Kalamazoo Valley

The Kalamazoo Valley Section met at the Columbia Hotel, Kalamazoo, Mich., on October 6. C. F. Hauck of the Hall Laboratories, Inc., Pittsburgh, Pa., talked on "Water Management and the Paper Industry."

The next meeting of the Section will be held on December 1 and will deal with "Dyeing."

Lake States

The Lake States Section met at the American Legion Club House, Appleton, Wis., on October 11. Otto Kress of the Institute of Paper Chemistry gave a talk on "Dyestuffs in the Paper Industry."

Ohio

The Ohio Section met on October 13, 1949, at the Hotel Manchester, Middletown, Ohio. After a short business meeting 128 members and guests heard Allen Abrams Vice-President in charge of Research of the Marathon Corporation give a very interesting talk on "Opportunities Through Research."

Research is fact finding, stated Mr. Abrams, and a laboratory consists of a group of organized fact finders. Research can be divided into (1) basic research—fact finding without a definite objective in view and (2) fundamental research—fact finding with a definite objective in view.

In setting up a research laboratory two important points must be considered, (1) the higher executives must definitely determine that the need exists, and (2) they must find a capable man to head up the laboratory. After the laboratory is established one principle is paramount if it is to succeed—research must report to the top echelon. The reports must be written in a manner so as to be easily understood by the nontechnical as well as the technically trained executives. The president of the company, or some one directly responsible to him, must outline plans, establish policy and be prepared to give help in planning the course of the investigations. Conferences to exchange ideas and acquaint others with the progress of the problems are extremely important as well as maintaining complete records on all experimental work.

The next meeting will be held at the Manchester Hotel, Middletown, Ohio, on December 8. The mobile water testing unit of the Ohio State Department of Health will be inspected. F. A. Waring will discuss Stream Improvement.

One of the Men behind Eastwood Wires

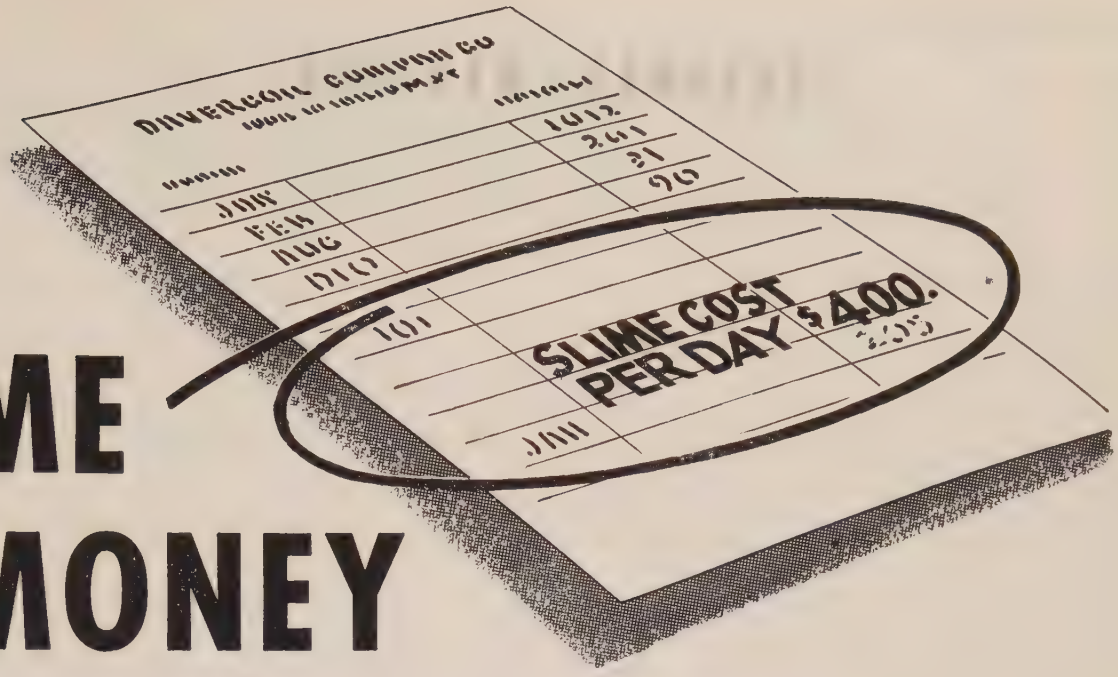
Harry Smith

"Stops the Music"

The ceaseless pounding of a giant wire loom may be nerve-wracking to some, but to Harry Smith it is harmonious accompaniment to his life's work. Here he has just stopped his loom to change the selvage wires at start of another Fourdrinier wire.

In his 38 years of service as a weaver for Eastwood-Nealley, Harry Smith has taken millions of feet of fine strand wire and fashioned them into meshes that made many kinds of paper in the finest paper mills of the country.

EASTWOOD-NEALLEY CORPORATION • Belleville, N. J.

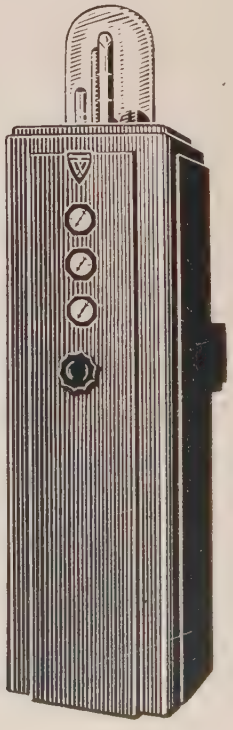


SLIME IS MONEY

Although you may never see a bill, studies show that slime costs the average paper mill $400 or more a day and is responsible for such costly troubles as wet end breaks, pin holes, slime spots, poor sheet formation, etc.

Break-Point Chlorination, engineered to your particular needs, has proven its slime fighting ability in hundreds of installations. This process, applied by dependable W&T Chlorinators, to your fresh water supply, often in conjunction with chloramines or other corrective chemicals to your stock or white water, gets results because it destroys the very cause of the trouble — slime forming bacteria. Moreover, members of W&T's nation-wide service organization with over 35 years' experience at their fingertips, carefully engineer each installation, to insure that you will receive maximum protection against slime at the lowest possible cost.

Your nearest W&T Representative will be glad to give you full details on how Break-Point Chlorination can cut your slime costs. Call him today.



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COMPANY, INC.
CHLORINE AND CHEMICAL CONTROL EQUIPMENT
NEWARK 1, NEW JERSEY • REPRESENTED IN PRINCIPAL CITIES

I-28

PERSONAL MENTION

Items About New and Old Tappimen

New TAPPI Members

Thomas S. Boerke, Sales and Service Engineer, Quaker Rubber Corp., Philadelphia, Pa., a 1944 graduate of the University of Maine.

Ernest A. Crawford, Engineering Supervisor, Continental Paper Co., Ridgefield Park, N. J., a 1929 graduate of the University of Missouri, School of Mining and Metallurgy.

Rae W. Davis, Special Representative, Allis Chalmers Mfg. Co., Norwood, Ohio, a 1906 graduate of University of South Dakota, and Massachusetts Institute of Technology in 1908.

Victor A. Denslow, Research Chemist, Cities Service Oil Co., East Chicago, Ind., a 1944 graduate of Cornell University.

G. Stuart Don, Editor, "Paper Maker & British Paper Trade Journal," London, England.

Hervey R. Emery, Jr., Steam Engineer, St. Regis Paper Co., Deferiet, N. Y., a 1942 graduate of Tufts College.

John A. Forster, Vice-President, Schultz-Forster Associates, Inc., Troy, N. Y., a 1936 graduate of Rensselaer Polytechnic Institute.

Roland E. Fortier, Tour Foreman, Brown Company, Berlin, N. H.

John D. Garber, Research Chemist, Merck & Co., Inc., Rahway, N. J., a 1940 graduate of Penn State College with a Ph.D. from the University of Illinois in 1943.

Elmslie W. Gardiner, Associate Director, California Research Corp., San Francisco, Calif., a 1922 graduate of the University of Alberta with a Ph.D. degree from the University of California in 1926.

Elsie L. Garvin, Librarian, Eastman Kodak Co., Rochester, N. Y., a 1920 graduate of the University of Vermont.

Clarence E. Grothaus, Research Associate, University of Kansas Research Foundation, a 1935 graduate of the University of Kansas with a Ph.D. degree.

Eric T. Guest, Acting Technical Supervisor, Bloedel, Stewart & Welch Pulp Mill Div., Port Alberni, B. C., Canada a 1944, graduate of Acadia University.

Edgard Harari, Engineer, Papeteries de France, Paris, France. Attended Ecole Centrale de Arts and Manufactures de Paris.

Burton E. Helberg, Senior Paper Technician, New York State College of Forestry, Syracuse, N. Y., and a 1941 graduate.

George P. Hinds, Jr., Assistant Chief Research Technologist, Shell Oil Co., Inc., Houston, Tex., a 1938 graduate of Tulane University, with an M.S. degree from California Institute of Technology in 1939.

Chikayuki Inouye, Mill Manager, Sanyo Pulp Co. Ltd., Yamaguchi-ken, Japan, a 1924 graduate of Kyoto University.

Milton V. Jones, Division Chief Draftsman, Mead Corp., Chillicothe, Ohio, a 1940 graduate of Ohio State University.

Albert B. Judson, Chemist, International Paper Co., Glens Falls, N. Y., a 1910 graduate of Lafayette College.

Richard T. Kropf, Vice-President and Director of Research, Belding Heminway Co., New York, N. Y., a 1931 graduate of Massachusetts Institute of Technology.

John M. Mallory, Junior Chemical Engineer, Union Bag & Paper Corp., Savannah, Ga., a 1949 graduate of University of Florida.

Maisteri M. Martola, Librarian, Teknillisen Korkeakoulun kirjasto, Helsinki, Finland.

George R. K. Moorhead, Sulphite Superintendent, Oregon Pulp & Paper Co., Salem, Ore., a 1925 graduate of Willamette University.

Roderick A. Perkins, Chemist, Oregon Pulp & Paper Co., Salem, Ore., a 1949 graduate of Oregon State College.

Hugh P. Quinn, Sales Engineer, The Bagley & Sewall Co., Watertown, N. Y.

Pieter A. Roelofsen, Professor, Technical University, Delft, Holland, a 1935 graduate of the University of Utrecht with a Ph.D. degree.

Howard W. Stephen, Chemist, National Container Corp. of Michigan, Ontonagon, Mich., a 1946 graduate of Indiana University.

John C. Stewart, Chemical Engineer, Goslin-Birmingham Mfg. Co., Inc., Birmingham, Ala., a 1947 graduate of Rose Polytechnic Institute.

Marrette Strain, Research and Systems Engineer, Continental Paper Co., Ridgefield Park, N. J., a 1941 graduate of Purdue University.

Walter J. Sullivan, Technical Sales, E. I. du Pont de Nemours, & Co., Inc., Boston, Mass. Attended Lowell Textile School.

William A. Tanzola, Assistant Director of Technical Div., W. H. & L. D. Betz, Philadelphia, Pa., a 1938 graduate of Drexel Institute.

Shu-Tung Tu, Chemist, University of Cincinnati and Tanexco Corp., Racine, Wis., a 1948 graduate of the University of Cincinnati with a Ph.D. degree.

Sue H. Weir, Order Librarian, Carnegie Library of Pittsburgh, Pittsburgh, Pa.

Allen W. Wiegand, Graduate Student, School of Forestry, University of California, Berkeley, Calif., a 1941 graduate of New York State College of Forestry with an M.S. degree in 1947.

James H. Young, Research Chemist, Straw Pulp Mfg. Co., Ltd., Radcliffe, Lancs., England, a 1932 graduate of the University of London.

TAPPI Notes

J. Ronald Atwater, Asst. to the President, Mead Sales Co., Inc., has been transferred from New York City to Dayton, Ohio.

Harrison G. Burbidge, Control Chemical, Provincial Paper Ltd., has been transferred from Port Arthur, Ont., to Mille Roche, Ont.

Arthur A. Bernhardt is now Technical Supervisor, KVP Co., Ltd., Espanola, Ont.

Kenneth G. Booth is now Chief, Experimental Pulping Section, Crown Zellerbach Corp., Camas, Wash.

John S. Barton is now Chief, Paper Products Development Section, Crown Zellerbach Corp., Camas, Wash.

Victor S. Burstine, formerly of the Michigan Paper Co., is now Manager Normandy Chemical Corp., Port Huron, Mich.

T. E. Button, formerly of the Continental Can Co., is now in the Sales Dept., St. Regis Paper Co., Los Angeles, Calif.

P. W. Bartholomew, formerly of the Hawthorne Paper

(continued on page 80 A)

ASTEN DRYER FELTS

- Complete Asbestos Surface on Sheet Side of Felt
- Pre-shrunk and Stretched
- High Porosity
- Long Life
- Low Cost per ton of Paper Dried

"The Most Popular Dryer Felt in the World"

ASTEN-HILL MFG. CO.

PHILADELPHIA, PENNSYLVANIA

ASTEN-HILL, Ltd., VALLEYFIELD, QUEBEC, CANADA

(continued from page 78 A)

Co., is now Asst. Sales Manager, Minnesota & Ontario Paper Co., 5940 Tenth Ave., Minneapolis, Minn.

C. M. Connor, formerly of the Ohio Boxboard Co., is now Director of Research & Development, W. C. Hamilton & Sons, Miquon, Pa.

William R. Csellak, formerly of the Institute of Paper Chemistry is now with the Gardner Board & Carton Co., Middletown, Ohio.

John Carson, formerly Superintendent, Columbia Paper Paper Co., Div., is now with the Mead Corp., Chillicothe, Ohio.

Thomas E. Dobbins is now Supervisor of The Nonmetallic Container Group, Research Div., American Can Co., Maywood, Ill.

Berle B. Babler, formerly of the Ohio Boxboard Co., is now Chief Chemist, Fleming & Sons, Dallas, Tex.

R. F. De Long, Bacteriologist for the Marathon Corp., has been transferred from Menasha, Wis., to Rothschild, Wis.

Kristian Fougner, formerly Engineer, Kennebec Div., Hudson Pulp & Paper Co., is now with Borregaard A/S, Sarpsburg, Norway.

George B. Hills, Jr., formerly with the University of Florida is now Asst. to the Production Manager, St. Joe Paper Co., Port St. Joe, Fla.

Robert C. Hesselbart, formerly with the Plaskon Div., Libby-Owens-Ford Co., is now Chief Chemist, Midwest Adhesive Co., Owosso, Mich.

Cleveland B. Hollabaugh, Consulting Engineer is now located at 163 Brompton Road, Garden City, N. Y.

James H. Hull is now Manager of Process Development, Crown Zellerbach Corp., Camas, Wash.

Walter F. Holzer is now Asst. Director of Research, Crown Zellerbach Corp., Camas, Wash.

William M. Hearon is now Asst. Director of Research, Crown Zellerbach Corp., Camas, Wash.

L. W. Heard, formerly of the Ontonagon Fibre Corp., is now a Consultant, 233 Eastlake Ave., Seattle 9, Wash.

J. H. Heuer has been appointed Acting Resident Manager of the Norfolk, N. Y., mill of the St. Regis Paper Co. He continues also as Technical Director for the Company.

James E. Johnson, formerly of the P. H. Glatfelter Co., is now Asst. Superintendent, Blandin Paper Co., Grand Rapids, Minn.

Julius P. Kovacs is now Vice-President in charge of Engineering, Purolator Products, Inc., Newark, N. J.

William H. Kennedy, formerly of the N. Y. State College of Forestry is now a Management Trainee, Hammermill Paper Co., Erie, Pa.

Glengarry D. King is now Manager of New Products Development, Crown Zellerbach Corp., Camas, Wash.

Hugo Klein, Consulting Chemical Engineer, is now located at 1914 East Orange Grove Ave., Pasadena, Calif.

Malcolm C. Lyon, Research Chemist, Champion Paper & Fibre Co., has been transferred from Canton, N. C., to Hamilton, Ohio.

Victor J. Molinski, formerly of the N. Y. State College of Forestry is now Chemist for the Allen B. Dumont Laboratories, Wood Ridge, N. J.

Ralph T. Nazzaro, formerly of the Premoid Products Inc., is now a Professor at the N. Y. State College of Forestry, Syracuse, N. Y.

Henry J. Ostrowski, formerly of Pacific Mills, Ltd., is now Owner of the Credit Valley Lime Co., Georgetown, Ont.

Frank T. Peterson, formerly of the Dilts Machine Co., is now Engineer for Black-Clawson International Ltd., London, Eng.

Miss Donna Price, formerly of the Hercules Powder Co., is now Research Chemist, Naval Ordance Laboratory, White Oak, Md.

Russell M. Pickens is now Vice-President in charge of Sales, Rayonier, Inc., New York, N. Y.

Josef E. Ryberg, formerly Consultant for the Chesapeake Camp Corp., is now with the National Newsprint and Paper Mills Ltd., Chandi, Burhanpur, India.

James Reid has retired from Robert Craig & Sons, Caldercruix, Scotland, and is now located at "Maryville," 257 Main St., Plains by Airdrie, Lanarkshire, Scotland.

Grant Swander, formerly of Time, Inc., is now Asst. Chief Inspector, Champion Paper & Fibre Co., Pasadena, Tex.

John C. Scarth is now Technical Supervisor, KVP Co. Ltd., Espanola, Ont.

Edward J. Sullivan, formerly of the Oxford Paper Co., is now Eastern Sales Manager, Gould Paper Co., New York, N. Y.

Robert G. Shirriff, formerly of the Kimberly-Clark Corp., is now Development Engineer, Coosa River Newsprint Co., Coosa Pines, Ala.

Sigurd Solvason, formerly of C. M. Guest & Sons, is now a Construction and Development Engineer, 2609 Gramercy Blvd., Houston, Tex.

Norton L. Speck is now a Junior Chemist, Dixie Cup Co., Easton, Pa.

Friedrich Teller, formerly of the Bengal Paper Mill Co., is now Planning and Design Engineer, The Australian Paper Mfgrs., Ltd., Melbourne, Australia.

Alexander W. Tait, Engineer for the International Paper Co., has been transferred from Palmer, N. Y., to Niagara Falls, N. Y.

William E. Van Voorhis, formerly of the University of Maine is now a Chemical Engineer for the S. D. Warren Co., Cumberland Mills, Me.

Gustave F. Williams of the Liberty Mutual Insurance Co., has been transferred from Atlanta, Ga., to New York City.

Ian Watson, formerly of the N. Y. State College of Forestry is now in the Technical Department, Mosinee Paper Mills Co., Mosinee, Wis.

A. Myles Younger is now Vice-President in charge of Sales for the Atlas Mineral Products Co., Mertztown, Pa.

* * *

Fred N. Sprague has succeeded Ken Moses as the Official Representative of the St. Regis Paper Co., in the Technical Association.

G. C. Smullen, Manager of the Casein Dept., has succeeded Nils Anderson as the Official Representative of the Borden Co., Chemical Div., in the Technical Association.

* * *

W. C. Huebner has removed the Huebner Laboratories from New York City to 102 Mamaroneck Ave., Mamaroneck, N. Y.

* * *

Jean Avot, General Director of Papeterie de la Seine, Naterre, France is visiting mills in the United States.

* * *

Individuals who may wish to present papers at the annual meeting of the Technical Association (February 20–23, 1950) should advise the Secretary of TAPPI, 122 East 42nd Street, New York 17, N. Y., by December 1.

Industry Notes

The Dunn Paper Co., Port Huron, Mich., celebrated its 25th Anniversary on October 9.

* * *

Walter A. Sherman, Superintendent of the Flambeau

(continued on page 82 A)

Night view of 100-octane plant at Standard of California's Richmond refinery—one of many whose combined output produces more than five hundred tailor-made petroleum products.

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Standard Oil Company of California

225 Bush St., San Francisco 20, Calif.

(continued from page 80 A)

Paper Co., claims that screen room production was increased by 20% through the use of the new Askania thin stock consistency control system. Details are obtainable from the Askania Regulator Co., 240 East Ontario St., Chicago 11, Ill.

* * *

The Research and Development Div., Buffalo-Chemical Co., Inc., Station B, Buffalo 7, N. Y., has compiled a booklet for general distribution on "Pulp Bleaching with Hydrogen Peroxide."

* * *

The general research laboratories of the Champion Paper & Fibre Co., are now in operation at Hamilton, Ohio. W. Phalti Lawrence and Malcolm Lyon, the Director and Asst. Director have moved to Hamilton from Canton, N. C. Morgan Robinson, Robert Green and Thomas Butler have also joined the Hamilton organization.

The building which is air-conditioned has been completely finished with vitreous tile and glass block. The first floor consists of a large central laboratory equipped for general pulp, paper, and coating research investigations, flanked with seven laboratories designed for two person occupancy. One the second floor there are private offices and the library, which also houses the Patent Dept. Personnel consists of a total 79 individuals, 39 of whom are professional.

* * *

Copies of a pamphlet "How to Do Business with the Quartermaster Corps" may be obtained from the Quartermaster Purchasing Office, 111 E. 16th St., New York 3, N. Y.; 226 W. Jackson Blvd., Chicago 6, Ill.; and Oakland Army Base, Oakland 14, Calif.

* * *

Copies of "Pulp, Paper and Board-Basic Information Sources," just released may be obtained at 10 cents per copy from the Department of Commerce, Washington 25, D. C.

* * *

W. & L. E. Gurley, Troy, N. Y., has just issued its new Bulletin No. 1400 describing its densometer, permeometer, Cobb sizing tester, S-P-S tester, and stiffness tester.

* * *

Westinghouse is building a 120 h.p. d.c. motor, one of the largest ever designed for a paper machine drive for delivery to the Enso-Gutzet paper mill in Finland. This motor will drive a shaft, the length of the machine, from which the various sections of the machine will be driven by belt and gear arrangements. The machine will produce paper 192 inches wide at 1500 f.p.m.

* * *

The Philadelphia Quartz Co., Public Ledger Bldg., Philadelphia 5, Pa., has just issued a 15-page booklet on "The Properties and Uses of Soluble Silicates."

EMPLOYMENT SERVICE

Positions Open

P36-49. Sales engineer, Papermaking Machinery firm in New England. Engineering or pulp and paper school education. Some mill experience. Age under 36.

P37-49. Production Manager for two mills. 3 paper machines making bonds, ledgers, vellums, and text papers from bleached wood plups. Good personality required. Practical man with technical education desired.

P38-49. Chief draftsman and engineer. Engineering degree required. 35–45. Mill makes sulphite and sulphate pulps and papers. Located in northeast.

P39-49. Machine Designer.—Prominent manufacturer of pulp and paper mill machinery has opening for experienced designing engineer. Give full details education and past connections in first letter.

Positions Wanted

E45-49. Technical or management position. 24 years' diversified experience in pulp and paper. Trained in research, development, and production of quality papers. Good background in pulping and stock preparation. Have operated two plants and had technical service experience.

E46-49. Technical or Production Director. Especially skilled in papermaking cost reduction and in paper treatment. 18 years' experience in medium and small organizations. Prefer Midwest location.

E47-49. Superintendent or tour boss. 45. Twenty-five years practical experience in technically controlled mill making book, bond, tissue, and fine papers. Knowledge of deinking.

E48-49. Mill instrument control engineer. 35. College graduate. 12 years' experience construction and maintenance.

Replies should be addressed to box number, c/o *Tappi*, 122 East 42nd St., New York 17, N. Y.

OBITUARY

C. Stewart Lee, director and retired vice-president, The Pusey and Jones Corporation

C. Stewart Lee, 76, director and retired vice-president of The Pusey and Jones Corp., Wilmington, Del., died October 4 in the Memorial Hospital in Wilmington where he was taken following in heart attack suffered at his home in that city.

Mr. Lee retired in January, 1948, after 40 years' service with The Pusey and Jones Corp. However, he retained his connection with the firm as a member of the board of directors. He began his career in the Puseyjones sales department in 1907 and was general manager of the company during World War I. He was made vice-president in 1924. Born in Baltimore, May 14, 1873, Mr. Lee was graduated from Loyola College in 1892. In his 40 years' affiliation with the Pusey and Jones Corp., active in the manufacture and sale of papermaking machinery, Mr. Lee visited virtually every important paper mill in the United States and Canada, and in this capacity traveled extensively in South America, England, western Europe, and Russia.

Surviving are his wife: Mrs. Elizabeth O'Donovan Lee; two sons, C. Stewart Lee, Jr., Wilmington; and Louis O'D. Lee, New York; two grandchildren; and five brothers and sisters.

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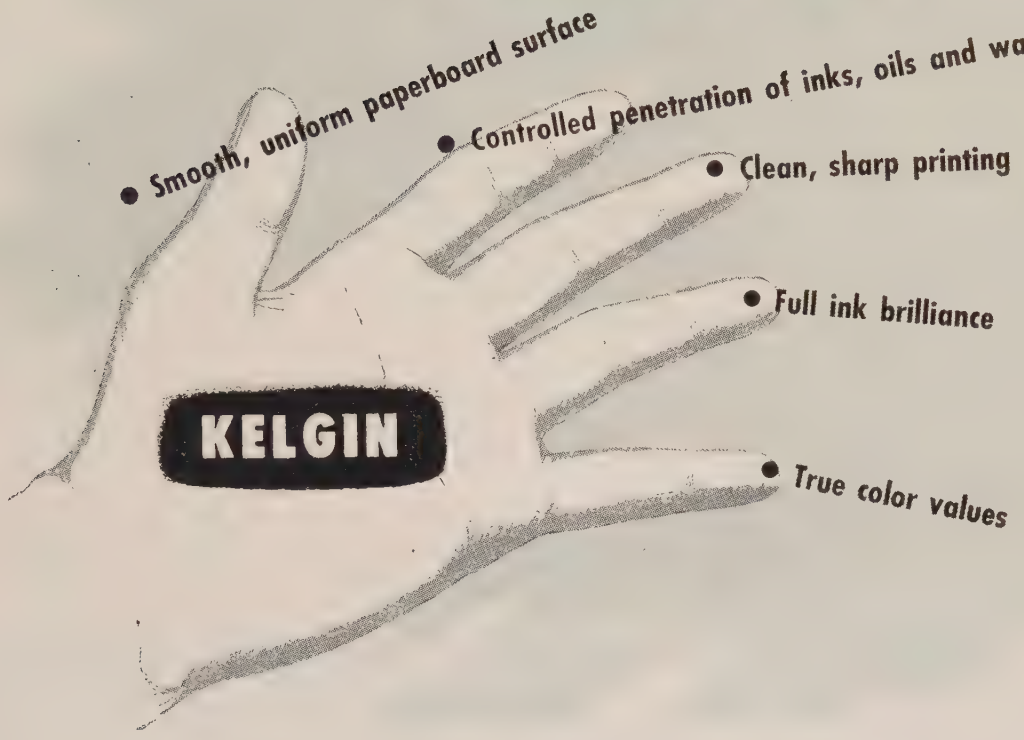

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Floor Load Capacity Rating and Its Relation To Industrial Power Trucks

CHAS. S. SCHROEDER

So SIGNIFICANT are the cost reductions which industry has found it can achieve through the use of unit-load material handling with industrial power trucks, that thousands of plants, both large and small, have swung over to the system. The trend has been going on for years now.

In the early applications such truck equipment was usually confined to ground floors where there was ample floor capacity to carry almost any type of machine. But today it is often found that further savings can be made by extending the material handling system to upper floors of multistoried buildings. The question immediately arises whether or not the floor has sufficient capacity to support the truck with its load, in addition to the material or machinery that may be stored on these floors.

Building construction varies widely, and for this reason it is impossible to make a precise recommendation without a detailed technical study of the plant involved. For this reason it is always recommended that a competent architect engineer study the plant in question in order to determine the weight of truck that would be permissible under the conditions obtaining.

In order to guide the engineer, a number of studies and tests have been made which should help the engineer in making his computations. This subject is important to industry, and, for this reason, truck manufacturers as a group have given much study to this problem, and have consulted many technical people in an attempt to arrive at a correct solution to the problem. As a starting point with a prospective application, it is always desirable to arrive at approximate figures yourself, to determine whether it is worthwhile to engage an engineer for a more detailed study. The following approach will serve this purpose.

The common types of industrial power trucks in use today impose a dynamic load to the floor of approximately 25% beyond the static weight of the loaded machine. This figure has been arrived at by numerous tests in actual plants, using both actual strain measurement on full-scale structures and special test setups.

Measuring apparatus was applied to the underside of the floor to indicate deflection of the structure. The truck was driven onto the floor and stopped in the center of a bay and the deflection noted. After this the truck was driven over the floor at full speed and the deflection noted. The truck was then run over an obstruction on the floor, causing a bump, with a corresponding increase in deflection. A further test was to drive the truck at full speed and come to a severe stop by applying the brakes, full power, in the middle of the bay, and the floor deflection noted. The load was raised and then lowered to the floor at full lowering speed, and the deflection of this impact noted. In all of these tests the maximum deflection noted was 25% in excess of the deflection caused by a loaded truck standing still. From the data thus compiled it is our judgment that a factor of 50% be allowed as a safe figure for the increase of dynamic loading over static loading.

An industrial truck does not exert its full weight at a fixed point, but instead distributes that weight at each of its four or six wheels, as the case may be. However, the wheelbase and the wheeltread of trucks which operate in multistoried buildings is relatively small, and for this reason we consider the truck as applying its load at a single point—i.e., exerting a concentrated load on the floor. Since the load is concentrated it will produce a bending moment approximately double that which would be produced by a uniform load on the beam structure of the floor. By this approach it is found that on a normal 20-by 20-foot bay our actual bending stresses in the floor slab are only approximately 85% as high as the computations would show if allowances were made for the actual wheelbase and wheeltread distribution. In other words, by considering the truck as applying a concentrated load, we allow a slightly higher factor of safety than necessary.

From the above we find that we have a factor of 1½ to 1 due to the dynamic loading, and a factor of 2 to 1 for the concentrated load conditions, making an over-all factor of 3 to 1 for the stresses in the floor slab imposed by a truck in operation, over that which would obtain on a uniformly loaded floor slab.

Our next problem is to find what portion of the floor slab is devoted to carrying the weight of the loaded truck. This may be determined by considering the area of space devoted to aisle in one bay. For example, if we assume a bay having 20- by 20-foot column spacing in which we allow an aisle 10 feet wide, we would have an aisle area of ten times twenty equals 200 square feet of unloaded floor area in one bay devoted to support of truck. If the floor has a rated capacity of 250 pounds per square foot this would allow us to store a load of $250 \times 200 = 50{,}000$ pounds of static load in this aisle space. This aisle space need only support the moving truck, hence we can determine the permissible loaded weight of the truck by taking 50,000 pounds and dividing it by a factor of three, which equals 16,000 pounds as the available floor capacity for the truck.

This calculation assumes that the area at either side of the trucking aisle is not loaded beyond the rated floor capacity, either with goods or production machinery. Two or more trucks could pass each other over this area in a given bay at one time provided the combined weight of trucks did not exceed the computed total, which in the above example would be 16,600 pounds. This point is very important in considering floor capacities, and shows up more particularly in front of elevators, where it is often found that one truck will be coming off the elevator before the second truck is run onto the elevator. For this reason particular attention should be paid to the area in front of elevators when designing new buildings or reinforcing old buildings.

A further caution in connection with the floor slab in front of an elevator arises from the facts that: (1) it usually gets more traffic than other sections of the building, (2) the fatigue load at this spot is likely, therefore, to be greater, and accordingly, (3) the floor should have a higher factor of safety. In addition it is often found that the column spacing in front of an elevator is less than that for other parts of the building. The length of aisle in that particular bay is shorter and has a lesser total carrying capacity if the floor at that point is thinned down to give the same static capacity per square foot as in other sections of the plant where the column spacing is normal. This condition, however, is somewhat offset by the fact that goods are seldom stored in such a bay. Where the entire bay can be devoted to supporting the weight of the loaded truck or trucks, the entire bay area may be used in the computations.

The foregoing obtains more particularly for the concrete slab type of floor construction, which, according to most architects, is one of the more desirable types of floor for buildings used as described above. Where other constructions are employed, further studies must be made, which in some cases will involve the actual wheel loading. This

(continued on page 86 A)

CHARLES S. SCHROEDER, Director of Engineering, The Yale & Towne Mfg. Co., Philadelphia, Pa.

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"IT'S not a big mill. In fact, it's a little mill. But it pays big dividends. Since installing Valley Equipment — we can run *complete pulp tests* and save the high cost of mill experimentation. We know, at all times, the quality characteristics of our pulp — and thus maintain continuous control of paper quality. It saves a lot of money — and we're turning out better paper!"

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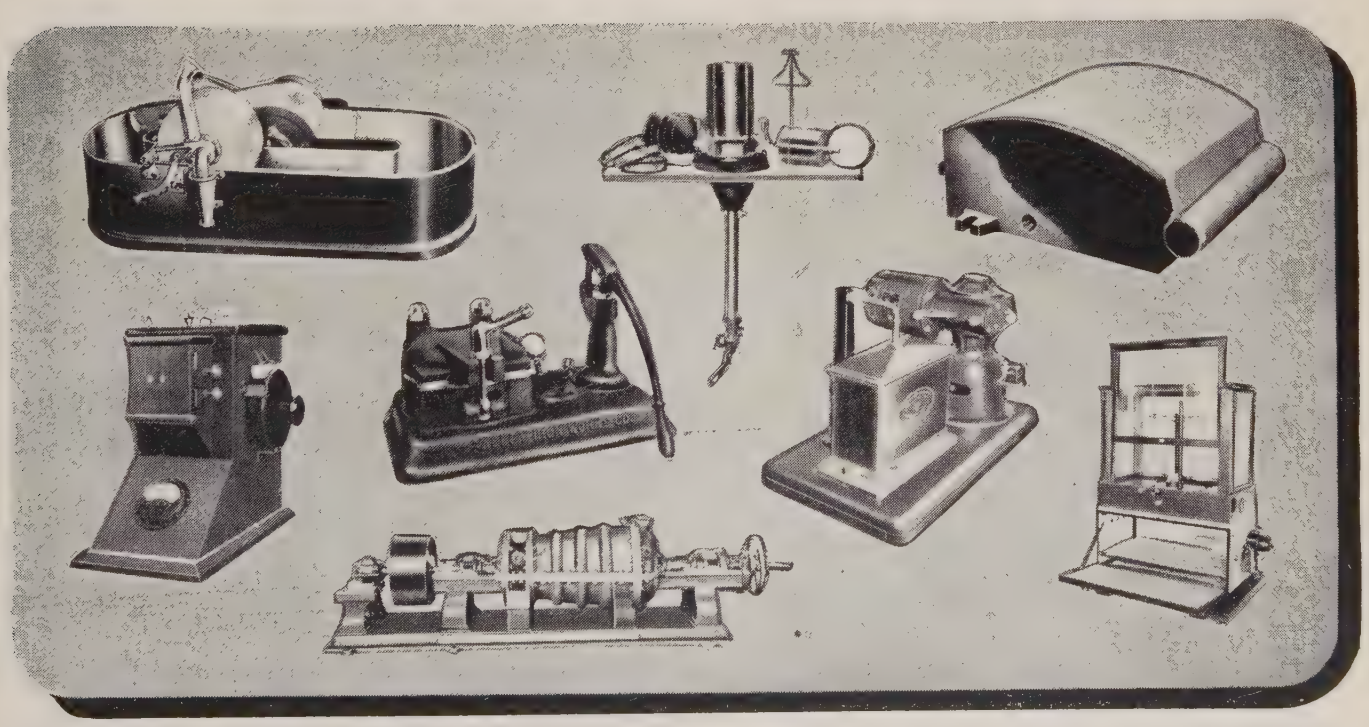

VALLEY *Laboratory Equipment*

(continued from page 84A)

is particularly true on wooden floors where only a few boards or planks may receive the entire load of a pair of wheels. Such a floor may be rated for a fairly heavy carrying capacity per square foot with a uniformly distributed load, but may not be capable of the concentrated loads produced by truck wheels, and in such cases, further computations (and possibly tests) may be indicated. An engineer-architect, in most such cases, could devise a reinforcing means (such as steel plates) to distribute the concentrated wheel loads over a greater number of planks.

Where steel beams are part of the concrete floor construction it is possible that concentrated loading may produce a problem because the span of the beams may be less than the span of the bay or the columns. This reduces the area devoted to supporting the truck, and a detailed study should be made to allow for such a condition. Where such construction is used the thickness of the concrete would be less, and because of this lesser thickness the stresses in the concrete due to concentrated loading may be increased even though the space between these beams is relatively small.

To summarize, simple study can give an approximate indication of the weight of the loaded trucks which may be safely operated on a floor. When these computations indicate that the weight of the trucks proposed approach the maximum figures, a detailed study by a competent engineer should be made. If the weight of the loaded machines is comfortably below the maximum figures, and the building is in a good state of repair, it would be safe to apply a trucking system without such a detailed engineering study.

Pennsalt Hydrogen Peroxide for Bleaching Groundwood

More and more paper manufacturers are showing interest in the use of Pennsalt Hydrogen Peroxide for bleaching groundwood. This interest is based on savings in production costs, increased yields from available wood, and superior qualities in specific grades of paper. With proper bleaching, it is possible to obtain maximum brightness and permit use of larger proportions of groundwood.

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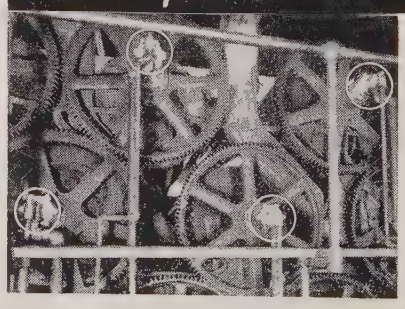

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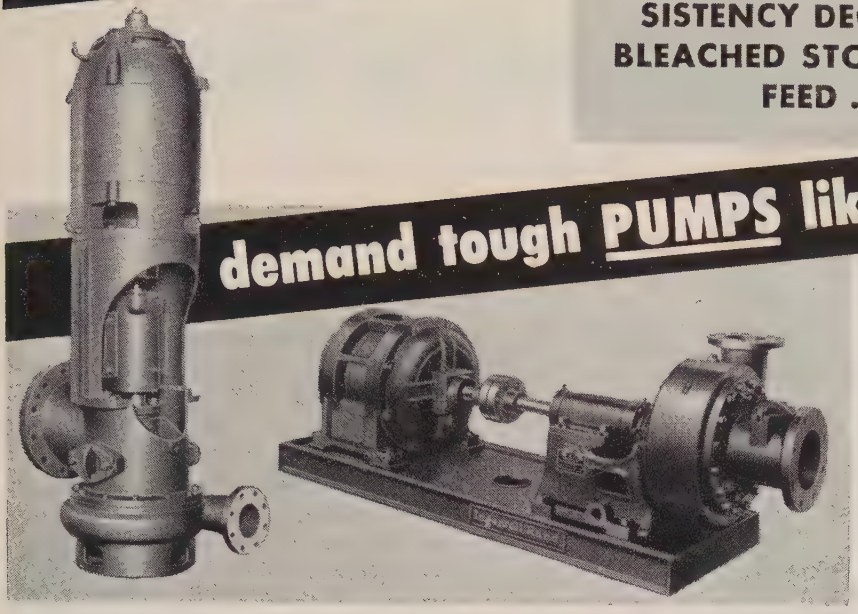

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Bacteriological Examination of Paper and Paperboard*

Revision of TAPPI Tentative Standard T 449 m-45

THE FOLLOWING procedure is recommended for the bacteriological examination of paper and paperboard. Because of the exacting technique required in bacteriological procedures, reproducible results can be secured only in the hands of a well trained technician.

APPARATUS AND MATERIALS

1. *Alcohol.* Methyl, isopropyl, or 95% denatured ethyl alcohol is used for sterilization of instruments.

2. *Balance.* This should be equipped with a platform approximately 6 inches in diameter to readily accommodate Petri dishes used. It should be sensitive to 0.1 gram.

3. *Bottles for Corkborers.* Screw-cap bottles large enough to hold one corkborer.

4. *Bottles for Dilution.* Several 8-ounce, narrow-mouthed, square-sectioned glass bottles fitted either with screw caps or with Escher rubber stoppers are used for water blanks. (Either tap or distilled water is satisfactory for dilution.)

5. *Colony Counter.* Any one of several types may be used. The Quebec, the Buck, and Wolffhuegel colony counters have been found satisfactory. A hand tally for recording the count is recommended.

6. *Containers for Dry Samples.* When the sampling and testing are done in the same mill, a single envelope may be employed; otherwise, two single envelopes, one placed inside the other, are used. The large one may be 9 by 12 inches and the smaller 6.5 by 9.5 inches. They should be made of a heavy kraft paper which will withstand sterilization in the hot-air even without embrittlement. After sterilization, the flap on the outer envelope is secured by pressure-sensitive tape.

An alternative is to make a folder of suitable size from heavy kraft paper and sterilize it in the oven. After the paper sample has been placed inside the sterile folder, the latter is sealed with the tape.

7. *Corkborer.* Standard corkborers 15 to 25 mm. in diameter, used for taking samples from rolls or sheets. These are sterilized in screw-cap bottles.

8. *Cotton.* Nonabsorbent cotton is used for plugs.

9. *Disintegrators.* Metal cup-type with a high-speed impellor near the bottom. A kraft paper cover is placed over each disintegrator cup or jar prior to its sterilization by steam heat.

10. *Flaming Equipment.* Depending upon the circumstances, an alcohol lamp, a gasoline blow-torch, or a Bunsen burner may be used to flame tongs, scissors, knives, and the mouths of sterile containers.

11. *Flasks.* Erlenmeyer flasks or bottles, preferably Pyrex, may be used as containers for sterile media.

12. *Incubator.* Capable of maintaining a temperature of 36 ± 1°C. (96.8 ± 1.8°F.), to provide proper incubation conditions for the inoculated plates.

13. *Knives.* A knife with an inserted blade (Stanley) may be used to cut paperboard. A paring knife with its blade cut down to within 1.5 inches of the base of the handle is also satisfactory.

14. *Petri Dishes.* Pyrex Petri dishes, 100 by 15 mm., are recommended for plating samples.

15. *Pipets.* Two sizes of pipets are used: 1.1-ml. milk-dilution type and graduated 10-ml. type. Mohr 10-ml. pipets, with tips cut off to give an opening of about 3 mm. in diameter at the delivery end, are best for pipetting fiber suspensions. Special Mohr pipets calibrated from the large end are available and preferable to the usual Mohr pipet. The pipets are sterilized in metal boxes or in heavy kraft paper.

16. *Scissors.* A satisfactory type has 4-inch cutting edges.

17. *Standard Nutrient Agar.* Difco dehydrated nutrient agar is recommended. It may also be prepared from the ingredients, according to the procedure outlined by the American Public Health Association (*1*). After the medium is dissolved, the hot mixture is placed in Erlenmeyer flasks, in bottles, or in test tubes and plugged with cotton. It is then ready to be sterilized.

18. *Sterilizing Equipment.* Two types are needed, the particular style and size depending upon the needs of each laboratory:

(a) A steam sterilizer, such as an autoclave or a pressure cooker.

(b) A hot-air oven. For most laboratories, electrically heated ovens are more satisfactory than those heated by gas, but the latter may be used if desired.

In both cases, thermometers are used to determine the inside temperature during sterilization.

19. *Tongs.* These are necessary for handling samples of paper.

STERILIZATION OF EQUIPMENT AND MEDIA

Depending upon the nature of the equipment to be sterilized, use one of three methods as follows:

1. Steam Heat

(Autoclaves and Pressure Cookers)

The following are sterilized by heating for 20 minutes

(continued on page 90 A)

* This revision has been approved as a tentative standard by the Water Committee. Criticisms are earnestly requested and should be sent to R. G. Macdonald, Secretary, Technical Association of the Pulp and Paper Industry. 122 E. 42nd St., New York, N. Y.

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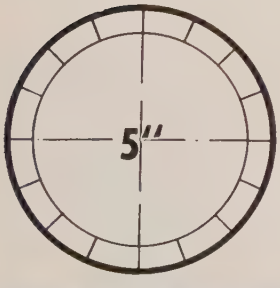

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SEMCO
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EASTERN BOULEVARD, WATERTOWN, NEW YORK

(continued from page 88 A)

at a minimum of 121°C. (250°F.) corresponding to 15 p.s.i. steam pressure: (a) cups and jars for disintegrators, (b) media (unless other conditions are specified by the manufacturer of the medium), (c) sample bottles, (d) corkborers, and (e) water blanks for dilution.

2. Dry Heat

(Electrically or Gas-Heated Ovens)

The following are sterilized by heating for at least 2 hours at a minimum temperature of 165°C. (330°F.): (a) heavy kraft envelopes and folders, (b) tongs, (c) knives, (d) Petri dishes, (e) pipets, and (f) scissors.

Care must be taken to dry glassware completely and to avoid over-heating and subsequent scorching of any paper containers or wrappers used on instruments that are being sterilized.

3. Alcohol

Scissors, tongs, knives, and similar instruments are immersed in alcohol and dried by burning off the alcohol. When needed for cutting or handling samples, remove the equipment from the liquid, let the alcohol drain off for a few moments, and then burn off the excess alcohol.

TEST SPECIMEN

Frequency of Sampling

Occasional single samples are inadequate, since the analyses reflect only the conditions which prevailed at the time when such samples were taken. The actual number of samples which should be taken depends largely on the reasons which prompt the analysis.

Method of Sampling

Method A. Use either a single envelope or two sterile envelopes, one within another, for each sample. Cut several layers of paper or paperboard from the area to be sampled with a sterile knife. Cut these sheets larger than the sample area and discard them to eliminate any surface contamination. In the exposed area then make a vertical cut with a sterile knife through several thicknesses near the center and parallel to the edge of the roll; a second vertical cut parallel to the first and about 5 inches from the first cut; and a horizontal cut across the bottom of the first two cuts, thus allowing the cut flap to spring out from the surface of the roll. Cut off and discard the top two sheets of the flap, then carefully open the sterilized envelope and slip the end of the cut flap of the sample into the envelope. Then make a horizontal cut across the top of the flap and about 6 inches from the bottom cut. The sample will then drop into the inner envelope; after which, seal the outer envelope by means of a pressure-sensitive tape. Secure a sample approximately 5 by 6 inches. Take two such samples at different sections of the roll.

This procedure can be adapted for sampling paper from skids, using flamed tongs for handling the samples of cut paper.

Method B. Remove several layers of paper or paperboard by cutting with a knife. Take the corkborer from the sterile bottle and cut about one half inch deep into the exposed area. Replace the borer, complete with the sample core, in the bottle.

TEST PROCEDURE

Preparation of Sample

Method A. Cut the envelope in which the sample is received along the flap by means of a sterile knife or scissors. Open the envelope by pressing the sides, without touching the inner surface, and remove the sample with sterile tongs. Hold the sample sheets in one hand, trim with sterile scissors and discard the outer edges. Make a series of cuts about $^1/_4$ to $^1/_2$ inch apart, parallel to the side of the sheet and opposite the edge held in one hand. Partially remove the cover of the tared Petri dish, but retain the cover on the pin of the balance. Cut squares of the sample directly into the dish by making a series of cuts perpendicular to those made previously.

Cut sufficient of the sample to make a 1% suspension of fibrous material after disintegration has been completed. (Nor less than a 2.0-gram sample should be used.) Replace the cover on the Petri dish, check the weight and aseptically adjust the excess or deficieny to obtain sufficient sample. Weigh to an accuracy of 0.1 gram.

Method B. Remove the corkborer containing the sample disks from the container. Eject with a sterile glass rod sufficient sample to make a 1% suspension of fibrous material after disintegration has been completed. (Not less than a 2.0-gram sample should be used.) Replace the cover on the Petri dish, check the weight and aseptically adjust the excess or deficiency to obtain the desired weight of sample. Weigh to an accuracy of 0.1 gram.

Disintegration

Remove the sample from the dish and place in a disintegrator cup or jar containing enough sterile water to give a fiber consistency of 1%. In adding material to the cup, do not touch the metal cap with the hands, but lift it by grasping the paper hood which was placed over the cup before sterilizing. Lift both hood and metal cap only enough to permit access to the cup. If several samples are to be examined, cool the water blanks to prevent the temperature of the disintegrated sample from exceeding 45°C. (113°F.) during disintegration. Let the paper hood remain on the cup at all times to prevent possible contamination through the opening in the metal cap or around the top of the cup.

Place the cup containing the weighed sample and sterile water in a mixing machine and run until disintegration is completed.

Plating

Plate the sample in a room which is relatively free of air currents and dust. About $^1/_2$ hour before plating, sponge the surface of the work table with a solution of a suitable toxicant, such as 5% phenol or 0.05% phenyl mercuric acetate, to further eliminate extraneous microorganisms.

The amount of fibrous material distributed over a given area of plate surface has been found to be an important factor in the number of colonies observed

(continued on page 92 A)

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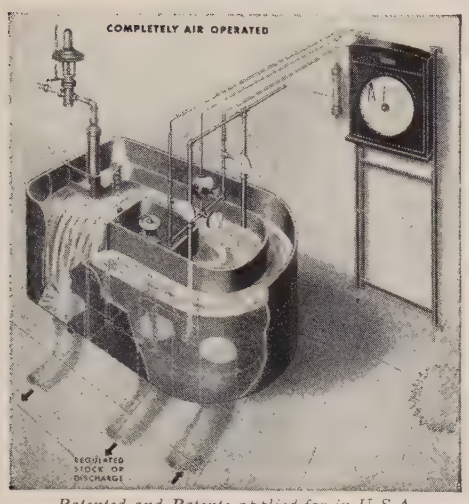

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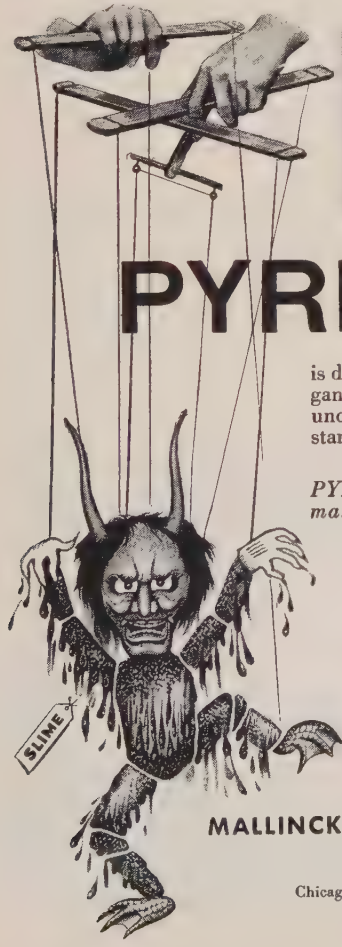

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(continued from page 90 A)

in a given sample of paper or board. Therefore, it is important to follow carefully directions regarding the fiber consistency, the volume of sample used for plating, and the number and size of plates used.

In culturing a disintegrated paper or board sample, distribute with a sterile pipet a total of 10-ml. of the pulped mixture in approximately equal proportions between five Petri dishes. Plate additional dilutions if it is suspected that the sample has a high bacterial population. Add to each plate 15 to 20 ml. of standard nutrient agar, cooled to about 45°C. (113°F.), then agitate the plates individually to disintegrate clumps of fibers and obtain an even distribution of the fibers in the medium, using a quick, short reciprocating motion. It is important that all lumps be broken up in order that the plates may be examined easily and accurately. Pour one control plate (without paper pulp) from each container of medium used.

Incubation

After the plates have been agitated, place them on a flat surface until the medium solidifies; then invert and incubate the plated samples at 36 ± 1°C. (96.8 ± 1.8°F.) for 48 hours. Do not stack the plates too closely in the incubator.

Counting Plate Cultures

After incubation, examine the cultures for the presence and number of bacterial colonies by holding the plates against a dark background, indirectly lighted. Plate counters are especially desirable.

If the sample has been separated into individual fibers and well mixed with the medium, the colonies, can be easily counted. If any particles are observed in the culture which can not be definitely identified as colonies, they should be examined microscopically. Plates with spreading colonies should be counted if at all possible, otherwise they should be reported as spreading colonies. Examine control plates also and make a record of the number of colonies found on the control for each sample.

REPORT

Results for paper or paperboard are expressed as the number of colonies per gram of sample examined. The consistency of the fiber suspension made of such samples is 1%; thus there is present 1.0 gram of stock in each 100 grams of suspension. A total of 10 ml. of the pulped mixture (0.10 gram of actual paper or paperboard) is cultured in five plates. Therefore, to obtain the number of colonies per gram of paper or paperboard, multiply by 10 the total number of colonies found on five plates.

In all cases record the count so that not more than two significant figures are used (*2*). For example, record a colony count of 142 as 140 and one of 145 as 150.

LITERATURE CITED

1. American Public Health Association, "Standard Methods for the Examination of Water and Sewage," p. 186, 9th Ed. (1946).
2. American Public Health Association, "Standard Methods for Examination of Water and Sewage," p. 193, 9th Ed. (1946).

Bacteriological Examination of Pulp

Revision of TAPPI Tentative Standard T 228 m-45

THE FOLLOWING procedure is recommended for the bacteriological examination of wet and dry pulp in sheet form. The procedure for examination of slush pulp is included in T 631 m. Because of the exacting technique required in bacteriological procedures, reproducible results can be secured only in the hands of a well-trained technician.

APPARATUS AND MATERIALS

1. *Alcohol.* Methyl, isopropyl, or 95% denatured ethyl alcohol is used for sterilization of instruments.

2. *Balance.* This should be equipped with a platform approximately 6 inches in diameter to readily accommodate Petri dishes. It should be sensitive to 0.1 gram.

3. *Bottles for Corkborers.* Screw-cap bottles large enough to hold one corkborer (8).

4. *Bottles for Dilution.* 8-ounce, narrow-mouthed, square-sectioned glass bottles fitted either with screw caps or with Escher rubber stoppers are used for water blanks. (Either tap or distilled water is satisfactory for dilution.)

5. *Bottles for Wet Samples.* Several 4- to 8-ounce. wide-mouthed, glass-stoppered bottles are used for collecting wet lap-stock samples. The type of bottle selected should be able to withstand sterilization. Prior to sterilization, the stoppers and the necks of the bottles are covered with metal foil or heavy kraft paper to protect the lip of the bottle from contamination. A strip of paper may be inserted in the mouth of the bottle to prevent sticking of the stopper during sterilization.

6. *Colony Counter.* Any one of several types may be used. Quebec, Buck, and the Wolffhuegel colony counters have been found satisfactory. A hand tally for recording the count is recommended.

7. *Containers for Dry Samples.* When the sampling and testing is done in the same mill, a single envelop may be employed; otherwise, two single envelopes, one placed inside the other, are used. The larger one may be 9 by 12 inches and the smaller 6.5 by 9.5 inches. They should be made of a heavy kraft paper which will withstand sterilization in the hot-air oven without embrittlement. After sterilization, the flap on the outer envelope is secured by pressure-sensitive tape.

An alternative is to make a folder of suitable size

(continued on page 94 A)

This revision has been approved as a tentative standard by the Water Committee. Criticisms are earnestly requested and should be sent to R. G. Macdonald, Secretary, Technical Association of the Pulp and Paper Industry, 122 E. 42nd St., New York, N. Y.

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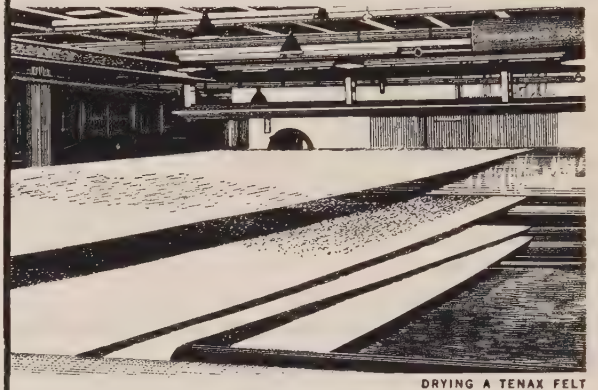

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(continued from page 92 A)

from heavy kraft paper and sterilize it in the oven. After the pulp sample has been placed inside the sterile folder, the latter is sealed with the tape.

8. *Corkborer.* Standard corkborers 15 to 25 mm. in diameter, used for taking samples from rolls or sheets. These are sterilized in screw-cap bottles.

9. *Cotton.* Nonabsorbent cotton is used for plugs.

10. *Disintegrators.* Metal cup-type with a high-speed impellor near the bottom. A kraft paper cover is placed over each disintegrator cup or jar prior to its sterilization by steam heat.

11. *Flaming Equipment.* Depending upon the circumstances, an alcohol lamp, a gasoline blow-torch or a Bunsen burner may be used to flame tongs, scissors, knives, and the mouths of sterile containers.

12. *Flasks.* Erlenmeyer flasks or bottles, preferably Pyrex, may be used as containers for sterile media.

13. *Incubator.* Capable of maintaining a temperature 36 ± 1°C. (96.8 ± 1.8°F.) to provide proper incubation conditions for the inoculated plates.

14. *Knives.* A knife with an inserted blade (Stanley) may be used to cut pulp. A paring knife with its blade cut down to within 1.5 inches of the base of the handle is also satisfactory.

15. *Petri Dishes.* Pyrex Petri dishes, 100 by 15 mm., are recommended for plating samples.

16. *Pipets.* Two sizes of pipets are used: 1.1-ml. milk-dilution type and graduated 10-ml. type. Mohr 10-ml. pipets, with tips cut off to give an opening about 3 mm. in diameter at the delivery end, are best for pipetting pulp suspensions. Special Mohr pipets calibrated from the large end are available and preferable to the usual Mohr pipet. The pipets are sterilized in metal boxes or in heavy kraft paper.

17. *Scissors.* A satisfactory type has 4-inch cutting edges.

18. *Standard Nutrient Agar.* Difco dehydrated nutrient agar is recommended. It may also be prepared from the ingredients, according to the procedure outlined by the American Public Health Association (*1*). After the medium is dissolved, the hot mixture is placed in Erlenmeyer flasks, in bottles, or in test tubes, and plugged with cotton. It is then ready to be sterilized.

19. *Sterilizing Equipment.* Two types are needed, the particular style and size depending upon the needs of each laboratory:

(a) A steam sterilizer, such as an autoclave or a pressure cooker.

(b) A hot-air oven. For most laboratories, electrically heated ovens are more satisfactory than those heated by gas, but the latter may be used if desired.

In both cases, thermometers are used to determine the inside temperature during sterilization.

20. *Tongs.* These are necessary for handling samples of pulp.

STERILIZATION OF EQUIPMENT AND MEDIA

Depending upon the nature of the equipment to be sterilized, use one of three methods as follows:

1. *Steam Heat*

(Autoclaves and Pressure Cookers)

The following are sterilized by heating for 20 minutes at a minimum of 121°C. (250°F.), corresponding to 15 p.s.i. steam pressure: (a) cups and jars for disintegrators, (b) media (unless other conditions are specified by the manufacturer of the medium), (c) sample bottles, (d) corkborers, and (e) water blanks for dilution.

2. *Dry Heat*

(Electrically or Gas-Heated Ovens)

The following are sterilized by heating for at least 2 hours at a minimum temperature of 165°C. (330°F.): (a) heavy kraft envelopes and folders, (b) tongs, (c) knives, (d) Petri dishes, (e) pipets, and (f) scissors.

Care must be taken to dry glassware completely and to avoid over-heating and subsequent scorching of any paper containers or wrappers used on instruments that are being sterilized.

3. *Alcohol*

Scissors, tongs, knives, and similar instruments are immersed in alcohol and dried by burning off the alcohol. When needed for cutting or handling samples, remove the equipment from the liquid, let the alcohol drain off for a few moments, and then burn off the excess alcohol.

TEST SPECIMEN

Frequency of Sampling

Occasional single samples are inadequate, since the analyses reflect only the conditions which prevailed at the time when such samples were taken. The actual number of samples which should be taken depends largely on the reasons which prompt the analysis.

Method of Sampling

(*a*) *Dry Pulp.* Method A: Use either a single envelope or two sterile envelopes, one within the other, for each sample. Cut several layers of the pulp from the area to be sampled with a sterile knife. Cut these sheets larger than the sample area and discard them to eliminate any surface contamination. In the exposed area make a vertical cut with a sterile knife through several thicknesses near the center and parallel to the edge of the bale or roll; a second vertical cut parallel to the first and about 5 inches from the first cut; and a horizontal cut across the bottom of the first two cuts. Tear off and discard the top sheet of the flap, then carefully open the sterilized envelope and slip the end of the cut flap of pulp into the inner envelope. Then make a horizontal cut across the top of the flap about 6 inches from the bottom cut. The pulp sample will then drop into the inner envelope; after which, seal the outer envelope by means of a pressure-sensitive tape. Secure a sample approximately 5 by 6 inches. Take two such samples at different sections on the bale or roll.

Method B: Remove several layers of pulp by cutting with a knife. Take the corkborer from the sterile bottle and cut about $^1/_2$ inch deep into the exposed area. Replace the borer, complete with the sample core, in the bottle.

(*b*) *Wet Pulp.* Sample by discarding the outer surface similarly to sampling dry pulp. Transfer the samples to sterile wide-mouthed bottles by means of sterile tongs.

(*c*) *Slush Pulp.* The method for sampling slush stock is similar to that employed for process water and is described in T 631 m.

TEST PROCEDURE

Preparation of Sample

(*a*) *Dry Pulp.* Method A: Cut the envelope in which the sample is received along the flap by means of a sterile knife or scissors. Open the envelope by pressing the sides, without touching the inner surface, and remove the dry lap with sterile tongs. Hold the sheet of pulp in one hand, trim with sterile scissors and discard the outer edges. Make a series of cuts about $^1/_4$ to $^1/_2$ inch apart, parallel to the side of the sheet and opposite the edge held in one hand. Partially remove the cover of the tared Petri dish, but retain the cover on the pan of the balance. Cut squares of pulp directly into the dish by making a series of cuts perpendicular to those made previously.

Cut sufficient pulp to make a 1% suspension of fibrous material after disintegration has been completed. (Not less than a 2.0-gram pulp sample should be used.) Replace the cover on the Petri dish; check the weight and aseptically adjust the excess or deficiency to obtain sufficient sample. Weigh to an accuracy of 0.1 gram.

Method B: Remove the corkborer containing the sample disks from the container. Eject with a sterile glass rod sufficient sample to make a 1% suspension of fibrous material after disintegration has been completed. (Not less than a 2.0-gram sample should be used.) Replace the cover on the Petri dish; check the weight and aseptically adjust the excess or deficiency to obtain sufficient sample. Weigh to an accuracy of 0.1 gram.

(*b*) *Wet Pulp.* Remove the sample from the bottle by means of sterile tongs. Hold the sheet in one hand, trim with sterile scissors and discard the outer edges. Complete the preparation as for (a) Dry Pulp.

Disintegration

Remove the sample from the dish and place in a disintegrator cup or jar containing enough sterile water to give a pulp consistency of 1%. In adding material to the cup, do not touch the metal cap with the hands, but lift it by grasping the paper hood which was placed over the cup before sterilizing. Lift both hood and metal cap only enough to permit access to the cup. If several pulp samples are to be examined, cool the water blanks to prevent the temperature of the disintegrated sample from exceeding 45°C. (113°F.) during disintegration. Let the paper hood remain on the cup at all times to prevent possible contamination through the opening in the metal cap or around the top of the cup.

Place the cup containing the weighed pulp sample and sterile water in a mixing machine and run until disintegration is completed.

Plating

Place the sample in a room which is relatively free from air currents and dust. About $^1/_2$ hour before plating, sponge the surface of the work table with a solution of a suitable toxicant, such as 5% phenol or 0.05% phenyl mercuric acetate, to further eliminate extraneous microorganisms.

The amount of fibrous material distributed over a given area of plate surface has been found to be an important factor in the number of colonies observed in a given sample of pulp. Therefore, it is important to follow carefully directions regarding the pulp consistency, the volume of sample used for plating (10 ml.), and the number and size of plates used.

In culturing a disintegrated pulp sample, distribute with a sterile pipet a total of 10 ml. of the pulped mixture in approximately equal proportions between five Petri dishes. Plate additional dilutions if it is suspected that the pulp has a high bacterial population. Add to each plate 15 to 20 ml. of standard nutrient agar, cooled to about 45°C. (113°F.), then agitate the plates individually to disintegrate clumps of pulp and obtain an even distribution of the fibers in the medium. using a quick, short reciprocating motion. It is important that all lumps of pulp be broken up in order that the plates may be examined easily and accurately. Pour one control plate (without pulp) from each container of medium used.

Incubation

After the plates have been agitated, place them on a flat surface until the medium solidifies; then invert and incubate the plate samples at 36 ± 1°C. (96.8 ± 1.8°F.) for 48 hours. Do not stack the plates too closely in the incubator.

Counting Plate Cultures

After incubation, examine the cultures for the presence and number of bacterial colonies by holding the plates against a dark background, indirectly lighted. Plate counters are especially desirable.

If the pulp has been separated into individual fibers and well mixed with the medium, the colonies can be easily counted. If any particles are observed in the culture which cannot be definitely identified as colonies, they should be examined microscopically. Plates with spreading colonies should be counted if at all possible, otherwise they should be reported as spreading colonies. Examine control plates also and make a record of the number of colonies found on the control for each pulp sample.

REPORT

Results for pulp are expressed as the number of colonies per gram of wet or dry pulp examined. The consistency of the fiber suspension of such samples is 1%; thus there is present 1.0 gram of stock in each 100 grams of suspension. A total of 10 ml. of the pulped mixture (0.10 gram of actual pulp) is cultured in five plates. Therefore, to obtain the number of colonies per gram of pulp, multiply by 10 the total number of colonies found on the five plates.

In all cases record the count so that no more than two significant figures are used (*2*). For example, record a colony count of 142 as 140, and one of 145 as 150.

LITERATURE CITED

1. American Public Health Association, "Standard Methods for the Examination of Water and Sewage," p. 186, 9th Ed. (1946).
2. American Public Health Association, "Standard Methods for the Examination of Water and Sewage," p. 193, 9th Ed. (1946).

Bacteriological Examination of Process Water

Revision of TAPPI Tentative Standard T 631 m-45

THE FOLLOWING procedure is recommended primarily for the bacteriological examination of process water. It is also applicable to pulp slush stock. Because of the exacting technique required in bacteriological procedures, reproducible results could be secured only in the hands of a well-trained technician.

APPARATUS AND MATERIALS

1. *Alcohol.* Methyl, isopropyl, or 95% denatured ethyl alcohol is used for sterilization of instruments.

2. *Balance.* This should be equipped with a platform to readily accommodate the dilution bottles. It should be sensitive to 0.1 gram.

3. *Bottles for Dilution.* Several 8-ounce, narrow-mouthed, square-sectioned glass bottles fitted either with screw caps or with Escher rubber stoppers are used for water blanks. (Either tap or distilled water is satisfactory for dilution.)

4. *Bottles for Samples.* Several 4- to 8-ounce, wide-mouthed, glass-stoppered bottles are used for collecting samples. The type of bottle selected should be able to withstand sterilization. Prior to sterilization the stoppers and the necks of the bottles are covered with metal foil or heavy kraft paper to protect the lip of the bottle from contamination. A strip of paper may be inserted in the mouth of the bottle to prevent sticking of the stopper during sterilization.

5. *Colony Counter.* Any one of several types may be used. Quebec, Buck, and the Wolffhuegal colony counters have been found satisfactory. A hand tally for recording the count is recommended.

6. *Cotton.* Nonabsorbent cotton is used for plugs.

7. *Flaming Equipment.* Depending upon the circumstances an alcohol lamp, a gasoline blow torch, or a Bunsen burner may be used to flame tongs, forceps, or the mouths of sterile containers.

8. *Flasks.* Erlenmeyer flasks or bottles, preferably Pyrex, may be used as containers for sterile media.

9. *Forceps.* These are used for handling stock of high consistency. Sterilize the forceps by flaming or by wrapping in kraft paper and sterilizing with dry heat.

10. *Incubator.* Capable of maintaining a temperature of 36 ± 1°C. (96.8 ± 1.8°F.) to provide proper incubation conditions for the inoculated plates.

11. *Petri Dishes.* Pyrex Petri dishes, 100 by 15 mm., are recommended for plating samples.

12. *Pipets.* Two sizes of pipets are used: 1.1-ml. milk-dilution type and graduated 10-ml. type. Mohr 10-ml. pipets, with tips cut off to give an opening about 3 mm. in diameter at the delivery end, are best for pipetting thick suspensions. Special Mohr pipets calibrated from the large end are available and preferable to the usual Mohr pipets. The pipets are sterilized in metal boxes or heavy kraft paper.

13. *Sampling Equipment.*

(a) Scoop. A tinsmith can make a simple scoop (Fig. 1) from a tinned iron sheet. The diameter of the scoop will depend upon the opening of the sample bottle, while the length is about 10 inches. A conveniently placed handle completes the scoop. The scoops are wrapped individually in heavy kraft paper and secured with either string or rubberbands. The unit is sterilized in a steam sterilizer.

(b) Spoon. A large spoon may be substituted for the scoop. It may be sterilized by autoclaving or at the point of use by alcohol immersion followed by flaming.

14. *Standard Nutrient Agar.* Difco dehydrated nutrient agar is recommended. It may also be prepared from the ingredients, according to the procedure outlined by the American Public Health Association (*1*). After the medium is dissolved, the hot mixture is placed in Erlenmeyer flasks, in bottles, or in test tubes and plugged with cotton. It is then ready to be sterilized.

15. *Sterilizing Equipment.* Two types are needed, the particular style and size depending upon the needs of each laboratory.

(a) A steam sterilizer, such as an autoclave or a pressure cooker.

(b) A hot-air oven. For most laboratories, electrically heated ovens are more satisfactory than those heated by gas, but the latter may be used if desired.

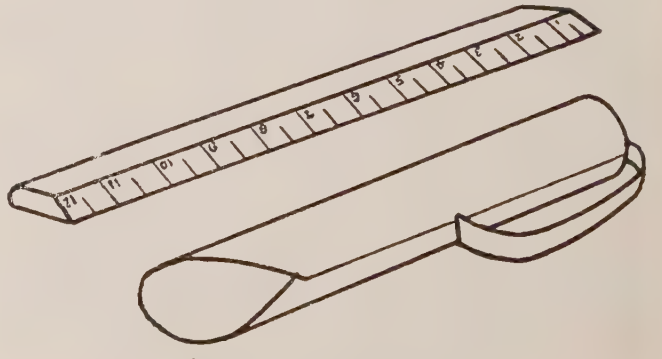

Fig. 1. Sampling scoop

This revision has been approved as a tentative standard by the Water Committee. Criticisms are earnestly requested and should be sent to R. G. Macdonald, Secretary, Technical Association of the Pulp and Paper Industry, 122 E. 42nd St., New York, N. Y.

In both cases, thermometers are used to determine the inside temperature during sterilization.

STERILIZATION OF EQUIPMENT AND MEDIA

Depending upon the nature of the equipment to be sterilized, use one of three methods as follows:

1. Steam Heat

(Autoclaves and Pressure Cookers)

The following are sterilized by heating for 20 minutes at a minimum of 121°C. (250°F.), corresponding to 15 p.s.i. steam pressure: (a) media (unless other conditions are specified by the manufacturer), (b) sample bottles, (c) scoops and spoons, and (d) water blanks for dilution.

2. Dry Heat

(Electrically or Gas-Heated Ovens)

The following are sterilized by heating for at least 2 hours at a minimum temperature of 165°C. (330°F.): (a) Petri dishes, (b) pipets, and (c) forceps.

Care must be taken to dry glassware completely and to avoid over-heating and subsequent scorching of any paper containers or wrappers used on instruments that are being sterilized.

3. Alcohol

Forceps and spoons are immersed in alcohol and dried by burning off the alcohol. When needed for handling samples, remove the equipment from the liquid, let the alcohol drain off for a few moments, and then burn off the excess alcohol.

TEST SPECIMEN

Frequency of Sampling

Occasional single samples are inadequate, since the analyses reflect only the conditions which prevailed at the time when such samples were taken. The actual number of samples which should be taken depends largely on the reasons which prompt the analysis.

Method of Sampling

(a) *Process Water or Low-Consistency Stock.* Use the sterile metal scoop or spoon for collecting samples of process water or stock. Dip a sample from the vat, chest or trough, using caution to avoid contamination of the sample from the hands coming in contact with the stock or from material adhering to the edges of the system. Transfer the sample to a sterile wide-mouthed bottle, replace the stopper or plug in the bottle, and retain the sample for dilution before plating.

It is frequently possible to introduce the sample directly into the bottle from a valve, faucet or pump outlet after proper flushing. Care should be taken that the sample or bottle is not contaminated by the hands during the sampling.

A simpler method of sampling may be employed in systems where there is a sufficient flow to prevent contamination. Hold the bottle by means of sterile tongs or grasp near the bottom with the hand, insert the mouth of the bottle into the flow of liquid, move the bottle into the flow, allow it to fill, remove the bottle and immediately replace its stopper.

(b) *High-Consistency Stock.* Use the sterile metal scoop or spoon for collecting the sample of slush stock. Dip a sample of the stock from the vat, chest or beater, using caution to avoid contamination of the sample from the hands coming in contact with the stock or from material adhering to the edges of the stock system. Transfer the sample to a sterile wide-mouthed bottle, replace the stopper or plug in the bottle, and retain the sample for dilution before plating.

TEST PROCEDURE

Dilution

(a) *Process Water or Low-Consistency Stock.* In making dilutions of process water or pulp suspensions measure 1 ml. of the sample into a sterile 99-ml. water blank and shake the mixture thoroughly. Remove the dilutions by the use of a sterile 1.1-ml. pipet. Transfer 1.0 ml. from the first water blank into a second water blank, agitate, and either dilute further or place portions in the Petri dishes. Follow this procedure until the desired dilutions have been made. It may be necessary to plate dilutions as high as 1:1,000,000; experience within a particular mill system will soon enable the bacteriologist to determine what dilution should be plated. In all cases the the aim should be to obtain plate counts in the range of 30 to 300 colonies per plate.

(b) *High-Consistency Stock.* Use a sample of 10 grams of high-consistency stock to insure greater accuracy of sampling. Weigh into a tared water blank containing 90 ml. of sterile water. Shake vigorously, using 20 complete cycles of vertical motion. Further-dilutions may be desired should the characteristics of the stock demand it.

Plating

Plate the sample in a room which is relatively free of air currents and dust. About $^1/_2$ hour before plating sponge the surface of the work table with a solution of a suitable toxicant, such as 5% phenol or 0.05% phenyl mercuric acetate to further eliminate extraneous microorganisms.

After the proper dilution of the process water or slush stock has been placed in Petri dishes, add approximately 15 ml. of standard nutrient agar, cooled to about 45°C. (113°F.), to each plate. Agitate the plates with a quick, short reciprocating motion to obtain an even distribution of the pulp fibers or the water. Pour one control plate from each container of medium used.

Incubation

After the plates have been agitated, place them on a flat surface until the medium solidifies; then invert and incubate the plated samples at 36 ± 1°C. (96.8 ± 1.8°F.) for 48 hours. Do not stack the plates too closely in the incubator.

Counting Plate Cultures

After incubation, examine the cultures for the presence and number of bacterial colonies by holding the plates against a dark background, indirectly lighted. Plate counters are especially desirable.

If, in the case of slush stock, the individual fibers have been well mixed in the medium, the colonies can be easily counted. If any particles are observed which cannot be definitely identified as colonies, they should be examined microscopically. Plates with spreading colonies should be counted if at all possible, otherwise they should be reported as spreading colonies. Examine control plates also and make a record of the number of colonies found on the control for each sample.

REPORT

For both process water and low-consistency stock, the results are expressed as the number of colonies per milliliter of sample examined. The results for slush stock of high consistency are expressed as the number of colonies per gram of stock examined. The number of colonies counted on the plates is multiplied by the dilution used in order to calculate the number per milliliter or per gram. In all cases record the count so that not more than two significant figures are used (*2*). For example, record a colony count of 142 as 140, and one of 145 as 150.

LITERATURE CITED

1. American Public Health Association, "Standard Methods for the Examination of Water and Sewage," p. 186, 9th Ed. (1946).
2. American Public Health Association, "Standard Methods for the Examination of Water and Sewage," p. 193, 9th Ed. (1946).

Analysis of Tall-Oil Skimmings*

TAPPI Tentative Standard T 635 m-49

In alkaline pulping processes using resinous woods the rosin and fatty acids in the wood are saponified and dissolve in the black liquor. When the black liquor is concentrated by evaporation, the rosin and fatty acid soaps plus some unsaponifiable material become insoluble and float to the surface. This mixture, which is skimmed from the surface of the black liquor, is called tall-oil skimmings. It is the raw material for producing tall oil.

This method deals with the testing of skimmings from the viewpoint of establishing its composition in terms of only those components which are considered of chief interest to skimmings producers and consumers. The tests include determinations of apparent density of skimmings, total solids in skimmings, yield of tall oil, and saponification number of the tall oil. From the results of these tests the composition of skimmings in terms of water, tall-oil soap, and other black liquor solids is established.

SAMPLING

If an appreciable amount of drainable black liquor is associated with the skimmings, it should be drained off and measured before sampling. In tanks or tank cars this may be most easily accomplished by measurements of volume before and after draining. The density of the black liquor is then measured and the weight drained is calculated. In small samples the weight of drained black liquor can be established by direct weighing before and after draining.

The representative sampling of the drained skimmings is difficult where large quantities are involved. In the case of tank car shipments a convenient procedure is to withdraw samples from the pump line continuously or at selected intervals during pumping. If continuous samples are withdrawn, care should be taken that there is no tendency to strain the skimmings from occluded black liquor at the sampling valve. In the case of tanks the problem is more difficult if the tank is not to be emptied at the time of sampling. If the tank contents can be recirculated, however, samples can be withdrawn continuously or at intervals from the recirculation line.

Small quantities of skimmings can be sampled reasonably well by agitating the whole quantity thoroughly before withdrawing the sample.

APPARENT DENSITY

Apparatus

1. *Wide-mouthed cylindrical vessel,* approximately 1-gallon capacity.
2. *Scale,* 10-pounds capacity, accurate to 0.01 pound.

Procedure

Establish the volume of the vessel by weighing it empty and then full to the brim with water of known temperature. The volume of the vessel in gallons is the weight of the water in pounds, divided by the density of water at the given temperature in pounds per gallon.

Fill the vessel with skimmings and adjust the level to the brim by passing a flat steel blade across the top. Weigh the vessel and its contents and deduct the tare. The apparent density of the skimmings in pounds per gallon (for the temperature at which the skimmings were weighed) is the weight of the skimmings, divided by the volume.

Report the result to the nearest 0.01 pound per gallon and include the temperature.

TOTAL SOLIDS

Apparatus

The apparatus is shown in Fig. 1 and consists of the following:

1. *Flask,* 500-ml. round bottom.
2. *Oil bath* which does not smoke excessively under 160°C.

* This method has been approved as a tentative standard by the Chemical Products Committee. Criticisms are earnestly invited and should be sent to R. G. Macdonald, Secretary, Technical Association of the Pulp and Paper Industry, 122 East 42nd Street, New York 17, N. Y.

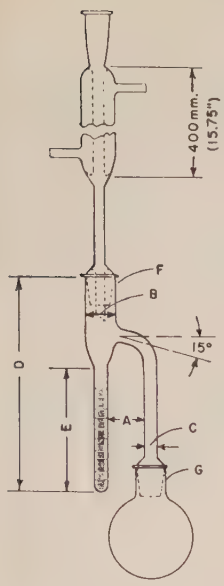

Fig. 1. Apparatus for moisture test

A = 45 to 55 mm.; *B* = 22 to 24 mm., inside diameter; *C* = 9 to 11 mm., inside diameter; *D* = 265 to 270 mm.; *E* = 155 to 165 mm.; *F* and *G* are interchangeable joints, standard taper 24/40.

3. *Condenser,* reflux, connected to flask and discharging into trap.
4. *Trap,* of well-annealed glass, constructed as in Fig. 1 and graduated to contain 10 ml. at 20°C. It is subdivided into 0.1-ml. divisions.

Reagent

Xylene, C.P.

Procedure

Weigh 10.00 grams of skimmings into the 500-ml. flask; add 100 ml. of xylene and stir. The xylene should be added as quickly as possible to prevent loss of moisture by evaporation. Connect the flask to the trap, which is then connected to the condenser. Lower the flask and connected apparatus into the oil bath. Heat the oil bath and distill slowly. The rate should be not over 200 drops per minute until all the water is collected in the trap. If any water adheres to the condenser, wash down with a 5-ml. portion of xylene. The drops of water adhering to the walls of the receiver are pushed to the bottom by moving a spiral copper wire up and down. Reflux at least 1 hour before shutting off the heat. Adjust the receiver contents to 20°C. and read the volume of water. Denote this as *V* ml. Then,

$$\text{Total solids, } \% = 10(10.00 - V)$$

Report the result to two significant figures.

TALL-OIL YIELD

Apparatus

Separatory funnels, 500-ml.

Reagents

A. *Diethyl ether,* free from nonvolatile residue.
B. *Hydrochloric acid* (concentrated HCl), sp. gr. 1.18 to 1.19.
C. *Sodium chloride* (salt) solution, 5% in water.
D. *Methyl orange indicator* solution.

Procedure

Weigh 5.00 grams of skimmings into a 500-ml. separatory funnel. Add 50 ml. of ether and 50 ml. of 5% salt solution, previously shaken together. Shake until the skimmings are dissolved. Add 1 or 2 drops of methyl orange indicator; then add HCl dropwise to slight excess and shake thoroughly. If the solution does not remain pink, add more acid until the indicator stays pink after shaking. Allow to stand for $^1/_2$ hour.

In a second separatory funnel shake 50 ml. of ether with 10 ml. of salt solution. Drain the aqueous bottom layer of the first funnel into the second funnel. Shake, let stand, and drain off the bottom layer into another funnel. Repeat four or five times until the ether extract is colorless. Combine the ether extracts (300 to 350 ml.) and wash twice with 50 ml. of water previously saturated with ether. Continue washing until the aqueous layer is neutral to methyl orange. Transfer about 175 ml. of the washed ether extract to a tared 250-ml. Erlenmeyer flask. Distill off the bulk of the ether on a steam bath through a cold-water condenser, cool the flask, and add the rest of the ether extract. Again distill off the bulk of the ether and then evaporate the remaining extract until free from ether. Remove any residual water by adding about 10 to 20 ml. of methanol and evaporating on a steam bath to constant weight. Save the extract for a saponification number determination as given below.

Calculate the weight of the dry extract as a percentage of the original sample and report the result to three significant figures as the Tall-Oil Yield.

TALL-OIL SAPONIFICATION NUMBER

Apparatus

Erlenmeyer flasks, 250-ml., of heat-resistant glass, preferably with 24/40 standard taper joint.

Reagents

A. *Alcoholic KOH solution* (0.5 *N*). Dissolve 33.0 grams of pure potassium hydroxide pellets or sticks (85% KOH) in methanol and dilute to 1 liter in a volumetric flask. The solution must be clear. If it contains insoluble matter, it shall be either decanted after settling over night or filtered. Standardize, preferably with potassium acid phthalate, to ±0.001 *N*.

B. *Sulphuric acid solution* (0.5 *N*). Standardize to ±0.001 *N*.

C. *Thymol blue solution.* Dissolve 0.1 gram in 100 ml. of methanol.

Procedure

Weigh 2.95 to 3.05 grams of the extracted tall oil from the above procedure into one of the 250-ml. Erlenmeyer flasks. Add 50.0 ml. of 0.5 *N* alcoholic KOH. Connect the flask to a water condenser, place in a water bath and allow the solution to reflux for $^1/_2$ hour. Cool and, without washing down the condenser, titrate immediately with 0.5 *N* H_2SO_4, using 1 ml. of thymol blue as indicator.

Conduct at least two "blank" determinations, using 50.0 ml. of 0.5 *N* alcoholic KOH. From the average titration of the blanks subtract the titration of the sample and report the number of milligrams of KOH consumed by 1 gram of the tall oil as its saponification number.

Calculation: 1 ml. 0.5 *N* KOH = 28.0 mg. KOH

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FINAL CALCULATIONS

Tall-Oil Soap

The per cent of tall-oil soap in the skimmings is obtained by the following calculations: (1) the per cent of sodium combined with tall oil in the skimmings is computed from the tall-oil yield and the saponification number; (2) the per cent of tall-oil soap (assumed to be sodium soap) is obtained by adding the per cent of tall oil in the skimmings to the per cent of sodium combined with it and subtracting the per cent of hydrogen replaced. These calculations are indicated below.

(A) % Sodium combined as soap

$$= \frac{\text{tall-oil yield} \times \text{saponification no.} \times 23.0}{56.1 \times 1000}$$

$$= \frac{\text{tall-oil yield} \times \text{saponification no.}}{410}$$

(B) % Hydrogen replaced $= \dfrac{(A)}{23.0}$

(C) % Tall-oil soap = tall-oil yield + (A) − (B)

Water

(D) % Water = 100 − % total solids

***Black Liquor Solids* (by difference)**

(E) Black liquor solids = 100 − (C) − (D)

REPORT

Report all final figures to two digits.

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Fibrous Agricultural Residues Conference, Terre Haute House, Terre Haute, Ind., November 7–8, 1949.

Annual Meeting: Commodore Hotel, New York, N. Y. February 20–23, 1950.

Fundamental Research Conference, Chateau Frontenac. Quebec, P. Q., May 29–30, 1950. Symposium: "The Papermaking Properties of Fibers."

LOCAL SECTIONS

PACIFIC SECTION:
December 6, 1949, The Monticello, Longview, Wash.
February 7, 1950, Engineering Meeting, Everett, Wash.

EMPIRE STATE SECTION:
Metropolitan Group:
January 10, 1950, Fraunces Tavern, New York City
Western New York Group:
December 14, 1949, Prospect House, Niagara Falls, N. Y.

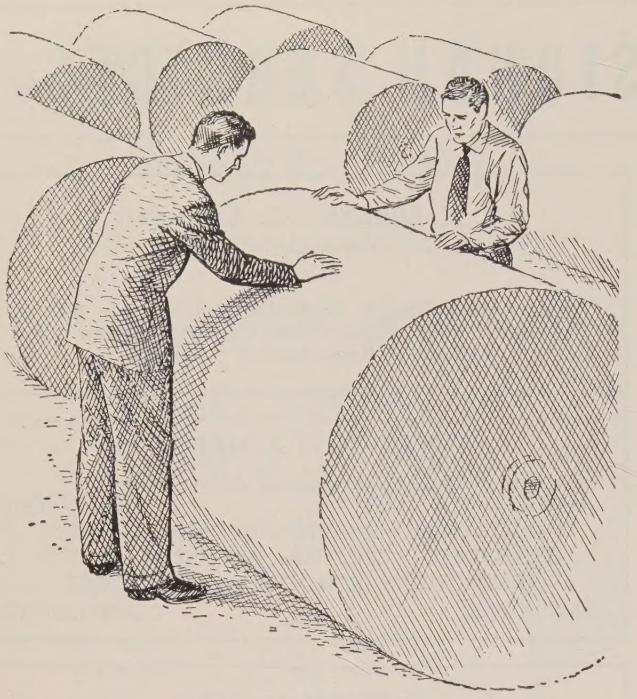
DELAWARE VALLEY SECTION:
November 30, 1949, Engineers Club, Philadelphia, Pa.
January 26, 1950, Engineers Club, Philadelphia, Pa.

OHIO SECTION:
December 8, 1949, Manchester Hotel, Middletown, Ohio
January 10, 1950, Manchester Hotel, Middletown, Ohio

KALAMAZOO VALLEY SECTION:
December 1, 1949, Columbia Hotel, Kalamazoo, Mich.

LAKE ERIE PAPERMAKERS AND CONVERTERS ASSOC.:
November 18, 1949, Hickory Grille, Cleveland, Ohio

CHICAGO SECTION:
November 21, 1949, Chicago Bar Assoc.



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American Cyanamid Co. ..... 21 A
American Defibrator, Inc. ..... 75 A
American Resinous Chemicals Corp. ..... 91 A
Appleton Wire Works, Inc. ..... 89 A
Appleton Wollen Mills ..... 87 A
Asten-Hill Mfg. Co. ..... 79 A
Atlas Mineral Products Co. ..... 46 A
Babcock & Wilcox Co. ..... 54 A
Bagley & Sewall Co. ..... 19 A
Bauer Bros. Co. ..... 62 A
Beloit Iron Works ..... 1 A
Bird Machine Co. ..... 39 A
Black Clawson Co. (Shartle, Dilts) ..... 48 A
Brown Instrument Co. ..... 3 A
Buffalo Forge Co. ..... 7 A
Buffalo Pumps, Inc. ..... 31 A
Butterworth & Sons Co., H. W. ..... 102 A
Cameron Machine Co. ..... 27 A
Chicago Bridge & Iron Co. ..... 57 A
Chiksan Co. ..... 73 A
Ciba Co. ..... 53 A
Dicalite Div., Great Lakes Carbon Corp. ..... 100 A
Dorr Co., The ..... 51 A
Dow Chemical Co. ..... 36 A
Downingtown Mfg. Co. ..... 11 A
Draper Brothers Co. ..... 93 A
Du Pont de Nemours Inc., E. I. (Dyestuffs) ..... 2 A
Du Pont de Nemours Inc., E. I. (Electrochemical) ..... 9 A
Du Pont de Nemours Inc., E. I. (Pigments) ..... 43 A
Eastwood-Nealley Corp. ..... 76 A
Egan & Co., Frank W. ..... 6 A
Foxboro Co. ..... 13 A
General American Transportation Co. ..... 4 A
Gottesman & Co. ..... 50 A
Gulf Engineering Co. ..... 100 A
Hercules Powder Co. ..... 2nd Cover
Hermann Mfg. Co. ..... 34 A
Hooker Electrochemical Co. ..... 17 A
Huyck & Sons, F. C. ..... 69 A
Ingersoll-Rand Co. ..... 87 A
Johns-Manville Corp. ..... 59 A
Johnson Corp., The ..... 86 A
Jones & Sons Co., E. D. ..... 45 A
Kelco Co. ..... 83 A
Langston Co., Samuel M. ..... 3rd Cover
Lockport Felt Co. ..... 93 A
Lodding Engineering Co. ..... 29 A
Lukens Steel Co. ..... 12 A
Mallinckrodt Chemical Works ..... 91 A
National Aniline Division ..... 35 A
Niagara Alkali Co. ..... 25 A
Nichols Engineering & Research Corp. ..... 65 A
Paper & Industrial Appliances, Inc. ..... 91 A
Pennsylvania Salt Mfg. Co. ..... 86 A
Perkins & Son, Inc., B. F. ..... 61 A
Perkins-Goodwin Co. ..... 4th Cover
Pusey & Jones Corp. ..... 33 A
Ranney Method Water Supplies, Inc. ..... 93 A
Rice Barton Research Corp. ..... 37 A
Rohm & Haas Co. ..... 23 A
Sandy Hill Iron & Brass Works ..... 8 A
Socony-Vacuum Oil Co. ..... 10 A
Southern Pulp and Paper Manufacturer ..... 49 A
Sprout, Waldron & Co. ..... 67 A
Standard Oil Co. of California ..... 81 A
Standard Oil Co. (Indiana) ..... 71 A
Stebbins Engineernig & Mfg. Co. ..... 89 A
Testing Machines, Inc. ..... 93 A
Texas Gulf Sulphur Co. ..... 52 A
Tracerlab, Inc. ..... 63 A
Valley Iron Works ..... 85 A
Vanderbilt Co., R. T. ..... 15 A
Waldron Corp., John ..... 47 A
Wallace & Tiernan ..... 77 A

PROFESSIONAL SERVICES

Calkin, John B. ..... 101 A
Ferguson, Hardy S. ..... 101 A
Howell, Charles M. ..... 101 A
Knowles Associates ..... 101 A
Main, Chas. T. ..... 101 A
O'Donoghue, Roderick ..... 101 A
Paper & Pulp Testing Laboratories ..... 101 A
Sirrine Co., J. E. ..... 101 A
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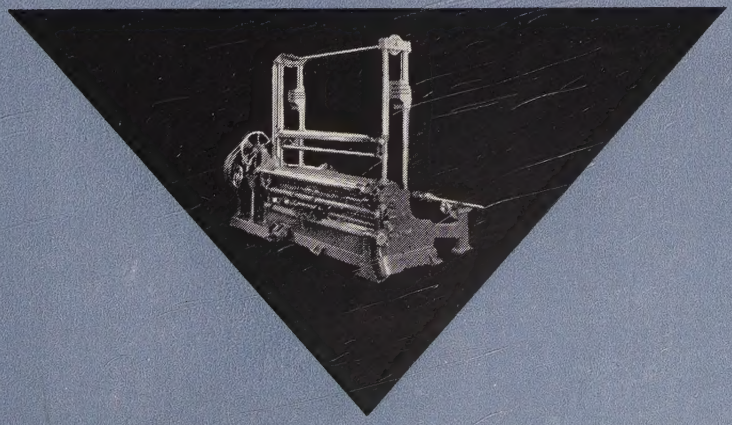

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